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THE U. S. S. *PENNSYLVANIA.*

BY LEWIS HOBART KENNEY, B. S., ASSOCIATE.

The U. S. armored cruiser *Pennsylvania* was built by the William Cramp and Sons Ship and Engine Building Company, Philadelphia, Pennsylvania. The contract was signed January 10, 1901, for the ship to be completed in thirty-six (36) months. This time was extended to August 10, 1904, and again to December 10, 1904. The hull was launched August 22, 1903. On September 15th and 16th, 1904, the port and starboard engines, respectively, were given a dock trial. The maximum pressure in the H.P. valve chest was 250 pounds and the corresponding revolutions per minute 88. There was no preliminary trial, and the ship left the yard of the builders November 12, 1904, for the official trial over the Cape Ann course. After leaving the Delaware Capes the ship proceeded to the Brooklyn Navy Yard, where she was dry-docked and painted, and also received her supply of coal. Here the lumps were picked out of the ship's supply of coal and bagged for the official trial. On the run from New York to Boston a forced-draft trial of about two hours' duration was held. The official trial over the Cape Ann course took

place November 23, 1904. The speed required by contract was 22 knots per hour.

PRINCIPAL DIMENSIONS OF HULL.

Length between perpendiculars, feet	502
on L.W.L., feet	502
over all, feet	504.04
Beam extreme, feet	69.54
at L.W.L., feet	69.54
Ratio of length to beam	7.22
Depth, molded, main deck, feet	41
Draught, normal, mean, feet	24.08
mean, on trial, feet	24.14
Displacement, normal draught, tons	13,780
trial mean, tons	13,817
per inch at L.W.L., normal draught, tons	57
Area of immersed midship section, normal draught, square feet,	1,595
L.W.L. plane, normal draught, square feet	23,940
Wetted surface, square feet	43,011
Center of gravity of L.W.L. plane, aft of M.S., feet	6.56
buoyancy above bottom of keel, feet	13.18
aft of M.S., feet	1.03
Transverse metacenter above center of buoyancy, feet	14.40
Longitudinal metacenter above center of buoyancy, feet	627.00
Coefficient of fineness, block	.5753
of M.S.	.9574
of L.W.L.	.6858
Cylindrical coefficients, longitudinal	.6009
vertical	.8389
Number of frames	124

MAIN BATTERY.

Four 8-inch B. L. R.'s, 45 calibers in length, in two balanced, electrically-operated-turrets.

Fourteen 6-inch R. F. guns, 50 calibers in length; ten on gun deck and four on main deck.

Eighteen 3-inch R. F. guns, 50 calibers in length; eight on gun deck, eight on main deck and two on boat deck.

SECONDARY BATTERY.

Twelve 3-pounders, semi-automatic; ten on boat deck and two on forward bridge.

Four 1-pounders, heavy, semi-automatic in lower tops.

Four 1-pounders, heavy, R. F. guns in upper tops.

Two 3-inch field guns on carriages.

Two machine guns, 30-caliber on top of turrets.

Six automatic guns, 30-caliber on forward and after bridges.

Two 18-inch submerged torpedo tubes (to be installed), will be located forward of the firerooms.

ARMOR.

Krupp steel for 5 inches and over, the rest is Harveyized.

Belt, 6 and 5 inches at top and bottom, respectively.

Protective deck, 1½ and 4 inches on top and slope, respectively.

Side, above belt, 5 inches.

Athwartship, 4 inches.

Turret gun, 6½ and 6 inches.

Barbettes, 6 and 4 inches.

6-inch gun positions, 5 inches.

2½-inch splinter bulkheads on gun deck.

⅞-inch splinter bulkheads on main deck.

MAIN ENGINES.

There are two main engines, each in a watertight compartment. They are outboard-turning, inverted, direct-acting, 4-cylinder, triple-expansion engines of the contractors' design. The arrangement of cylinders is the H.P. forward; aft of it is the M.P., F.L.P., and A.L.P., respectively, and are connected to prevent athwartship motion only.

The crank shaft is arranged with the H.P. and M.P., also F.L.P. and A.L.P., cranks 180 degrees apart. This makes the sequence of cranks H.P., F.L.P., M.P. and A.L.P. with a 90 degree interval. The crank shaft is in four sections and designed so that the H.P. and M.P. sections are interchangeable, and also the F.L.P. and A.L.P. sections.

The cylinders are supported on inverted Y cast-steel housings on the inboard side, and forged-steel columns outboard. Diagonal braces extend from the bottom of the columns to the top of the housings. There are two braces per housing. Longitudinal braces extend through the steel columns, and tie rods

connect the tops of columns and housings between cylinders. On the inboard side of the housings is located the reverse shaft. The turning engine is also located on the inboard side of the engines and the throttle valve on the outboard side. All handling gear is located between the H.P. and M.P. housings, and the engine-gauge board is directly back of it on the centerline bulkhead. Jacket steam passes through the top, sides and bottoms, successively, of each cylinder. It is admitted through a reducing valve to the top of the H.P. cylinder and exhausted through a second reducing valve to the top of the M.P. cylinder. It exhausts from this cylinder through a third reducing valve to the top of the L.P. cylinders. The drain from the L.P. jackets is to a trap which discharges to the filter and feed tanks. The clothing material for all cylinders is composed of 85 per cent. carbonate of magnesia, and 15 per cent. asbestos fiber, lagged with Russia sheet iron.

Piston valves used on all cylinders are operated by the Stephenson double-bar link motion with adjustable cut-off. There are five graduations for the points of cut-off on each reverse-shaft arm and are for the down stroke only.

The material for cylinders is cast iron, fitted with close grained, hard cast-iron piston and valve-chest liners. The steam-jacket space is between the piston liner and cylinder body. The body of the H.P. piston valve is cast iron, and of the M.P. and L.P. valves steel pipe with cast-iron heads. The packing rings, of hard cast iron, are designed to prevent expansion beyond a given diameter, but will permit contraction. The H.P. valve stem is connected to the link block, and the M.P. and L.P. valve stems to a cast-steel crosshead which is connected to the link block. The crosshead guides—also of cast steel—are bolted to the valve chests. The suspension links the reverse shaft and eccentric rods, also valve stems, are high-grade machinery forgings.

Data for Cylinders:	H.P.	M.P.	L.P.
Diameter of cylinders, inches	38½	63½	74
Stroke, inches	48	48	48
Thickness of body, inches	2½	2	1¾

	H.P.	M.P.	L.P.
Thickness of liner, inches	1⅝	1⅝	1½
jacket space, inches	¾	¾	¾
valve chest, inches	1⅝	1½	1⅝
Number of studs for cylinder cover	48	60	42
Diameter of studs for cylinder cover, inches	1⅝	1⅝	1⅝
Pitch of studs for cylinder cover, inches	3.5	4.8	7.7
Number of studs for valve-chest cover	28	26	18
Diameter of studs for valve-chest cover, inches	1½	1⅜	1⅜
pitch circle, inches	33½	32⅓	34½
Number of tap bolts for piston liner	22	36	42
Diameter of tap bolts for piston liner, inch	⅞	⅞	⅞
pitch circle for piston liner, inches	36½	61½	72
Number of piston valves	1	2	2
Diameter of piston valves, inches	26	26	28
balance pistons, inches	6	6	10
Port area through valve-chest liner, square inches	209	228	273
Valve travel, inches	10½	10½	10½
Taken from Port Engine:			
Steam lead, top, inch	1/16	⅛	⅛
bottom, inches	1 3/16	1¼	1 3/16
First cut-off, down stroke, per cent	80	77	78
Second cut-off, down stroke, per cent	70	63	67
Third cut-off, down stroke, per cent	57	45	51
First cut-off, up stroke, per cent	77	71	72
Diameter of valve stem through gland, inches	3½	3½	3½
valve, inches	2	2	2
Area of valve-stem crosshead (each side), square inches	27	66	66

Pistons.—The pistons are conical shaped and made of cast steel, finished all over. The upper end is threaded for a nut to be used when removing the piston from its rod. Cast steel is also used for the follower ring, which is held in place by square-necked studs.

The packing rings are of hard cast iron, designed to prevent expansion beyond a given diameter, but allow lineal expansion.

Number of packing rings per piston	2
Width of packing rings, bearing surface, inches	1½
Thickness of packing rings, inches	1
Number of follower studs, H.P	12
M.P	20
L.P	20
Diameter of follower studs, inches	1½

Piston Rods, Crossheads and Crosshead Slippers.—The piston rods and crossheads are high-grade machinery forgings and the crosshead slippers of Parson's manganese-bronze, faced with white metal. The ends of the piston rods are tapered to fit in the piston and crosshead. Crosshead pins on each end of the crosshead are bored out for oil reservoirs. The crosshead is bolted to the slipper. The crosshead guides are of cast iron, made hollow for the water service, and the backing guides are of the same material. They are bolted to the housings.

	H.P. & M.P.	L.P.
Diameter of piston rod, inches	8½	8½
piston-rod hole, inches	4½	5
crosshead pin, inches	11½	9½
Length of crosshead pin (each), inches	12½	10½
slipper, inches	34	34
Width of crosshead slipper, inches	27	18
Length of backing surface, inches	34	34
Width of backing surface (each), inches	9½	6½

Connecting Rods, Crank Shafts and Bed Plates.—The connecting rods and crank shafts are high-grade machinery forgings The upper ends of the connecting rods are forked for the crosshead-pin brasses. These brasses and the crank-pin brasses are lined with white metal. All rods and the crank shafts are hollow. The hollow crank pins are used for oil reservoirs.

The bed plates and main bearing caps are cast steel. The caps and bottom brasses are hollow for water service and lined with white metal. The bottom brasses are circular to facilitate removal.

	H.P. & M.P.	L.P.
Length of connecting rod, center to center, inches	96	96
Diameter of connecting rod, top, inches	7½	6½
bottom, inches	8½	7½
holes, inches	2	2
crosshead-pin bolts, inches	3½	3
Number of crosshead-pin bolts, per rod	4	4
crank-pin bolts, per rod	2	2
Diameter of crank-pin bolts, inches	5	4
Length of crank pin, inches	22½	15
Diameter of crank pin, inches	20	

	H.P. & M.P.	L.P.
Diameter of crank-pin hole, inches	12	
crank shaft, inches	18½	
crank-shaft hole, inches	10	
coupling flanges, inches	32½	
Width of coupling flanges, inches	4½	
Number of coupling bolts	8	
Diameter of coupling bolts, inches	3¾	
pitch circle, inches	26	
Width of crank webs, inches	21½	
Thickness of crank webs, inches	11½	
Number of bearings	8	
Length of bearings, H.P. and M.P., inches	23	
F.L.P., inches	15½	
A.L.P., inches	15½ and 18½	

	H.P. & M. P.	L.P.
Diameter of main bearing bolts, inches	4⅜	3¾
Number of main bearing bolts, per bearing	2	2

Reversing Engine.—The reversing engine is located between the L.P. cylinders with its steam cylinder bolted to the outboard side of the main engine bedplate. There is an oil-control cylinder of brass connected to the steam cylinder by tie rods, which serve as crosshead guides. Braces from the housings to the oil cylinder hold it firmly in place. One piston rod extends through each cylinder and is made of forged steel. The tail rod in the oil cylinder is brass. A hand oil pump, located near the handling gear of the main engines, is connected to the oil cylinder. The reverse shaft is near the top of the inboard side of the housings, and the levers are connected to the crosshead of the reverse engine by two forged-steel connecting rods. Differential levers control the valve mechanism.

Data for Engine:

Diameter of steam cylinder, inches	16
oil cylinder, inches	10
steam piston rod, inches	3⅜
oil piston rod, inches	3
tail rod, inches	3
Length of crosshead bearing, inches	10
Width of crosshead bearing each side, inches	2½
Length of crosshead pin, each, inches	3½
Diameter of crosshead pin, each, inches	3½

	H.P. & M.P.	L.P.
Diameter of tie rods between cylinders at crosshead bearing, inches	3	
ends, inches	2⅝	
connecting rods, end, inches	2½	
middle, inches	2⅝	
Length of connecting rods, feet and inches	7– 2¾	
reverse levers, inches	17⅝	
Diameter of reverse shaft, inches	8½	
bearings, inches	8½, 7, 5	
Length of bearings, inches	8½, 8½, 8½	

Turning Engine.—The turning engine is located on the forward side of the F.L.P. housing with the crank shaft horizontal. The shaft extends outboard to a roller bearing bolted on a steel column; for turning the main engines by hand the end of this shaft is made square to fit a wrench. The worm on the crank shaft engages a wheel at the top of a vertical shaft, and on this shaft is a second worm, prevented from turning by a feather but may be moved vertically to engage or disengage with the wheel on the main crank shaft. The step bearing for this vertical shaft is on the engine foundations. A plug cock designed to reverse the direction of the steam and exhaust is used to reverse the engine.

The time required to turn the main-engine crank shaft through one revolution is about three and one-half minutes.

Data for Turning Gear:

Number of cylinders	2
Diameter of cylinder, inches	8
piston rod, inches	1½
valve, inches	2½
Stroke, inches	8
Valve travel, inches	1½
Crank angle, degrees	90
Area of crosshead slipper, square inches	23
Diameter of crosshead pin, inches	2
Length of crosshead pin, inches	2½
Diameter of crank pin, inches	2½
Length of crank pin, inches	3⅝
Diameter of crank-shaft, inches	2½
Length of crank-shaft bearings, inches	4, 6
Diameter of pitch circle of worm, inches	4½
wheel, inches	14½
Number of teeth	30

Diameter of pitch circle of vertical worm, inches	9.68
wheel, inches	57.30
Number of teeth	60
Diameter of vertical shaft, inches	4
Area of step bearings, square inches	26

Shafting and Thrust Bearing.—The shafting is installed in four sections—thrust, line, stern-tube and propeller—of high-grade machinery forged steel, oil tempered. The line and stern-tube shaft coupling is made as follows: A forged-steel ring fits on the end of the stern-tube shaft—four keys prevent it rotating—and into a circumferential groove in the shaft are fitted two half rings. The coupling bolts go through the steel ring, the half rings and the flange of the line shaft. Into the outboard coupling sleeve the shafts are tapered and are held in place by longitudinal and through keys. The stern-tube shaft is encased in composition casings and the space between them and the shaft is filled with rosin and tallow.

The thrust bearing is of the horseshoe type. The body is of cast iron, so shaped that it forms a reservoir for oil. The shaft bearings at the ends are fitted with glands to prevent the leakage of oil. To the foundations is riveted the sole plate, and the thrust-bearing body is bolted to this, there being steel wedges at each end to provide for longitudinal adjustment.

The thrust shoes are cast steel, hollow for water service, and faced with white metal. At the top is an oil reservoir and from it are oil-ways to the bearing faces.

Data for Shafting:

Diameter of thrust shaft, inches	17½
hole, inches	10
Number of thrust-shaft collars	13
Outside diameter of thrust-shaft collars, inches	28
Width of thrust-shaft collars, inches	2
space of thrust-shaft collars, inches	4½
Length of thrust-shaft bearing, inches	18½
Number of thrust shoes	12
Diameter of thrust side rods, inches	4
line shaft, inches	17½
Diameter of line shaft hole, inches	10½
Length of steady bearing, inches	24
Diameter of stern-tube shaft, inches	18½

Diameter of stern-tube shaft hole, inches	10½
Length of stern-tube forward bearing, inches	41⅝
after bearing, inches	54½
Diameter of propeller shaft, inches	18½
hole, inches	10½
Length of forward strut bearing, inches	30
after strut bearing, inches	57⅝
Diameter of coupling flange, inches	32½
Thickness of coupling flange, inches	4½
Number of coupling bolts	8
Diameter of coupling bolts, inches	3¾
Diameter of coupling bolts, pitch circle, inches	26
Length of outboard coupling sleeve, inches	72
Outside diameter of outboard coupling sleeve, inches	24
Width of longitudinal keys, inches	2½
Depth of longitudinal keys, inches	1½
Width of through keys, top, inches	8
bottom, inches	7
Thickness of through keys, inches	2½

Propellers.—The propeller blades and hubs are manganese-bronze. The hub is fitted on the tapered end of the propeller shaft and held in place by one longitudinal key and a nut on end of shaft threaded in the opposite direction to the rotation of the propeller. The blades fit in recesses in the hub and are held in place by rolled manganese tap bolts—a small casting fitting between the bolts prevents their turning. The pitch is adustable by making the bolt holes elongated, and is variable, due to the working surface being made slightly convex. The propeller was carefully balanced, file finished all over, and tinned.

The starboard propeller rotates in a clockwise direction, and the port in a counter clockwise direction.

Data for One Propeller:

Number of blades	3
Diameter of propeller, feet and inches	18– 0
Pitch for official trial, feet and inches	22– 0
maximum, feet and inches	23– 6
minimum, feet and inches	20– 6
Ratio of pitch to diameter	1.22
Helicoidal area, square feet	92
Projected area, square feet	74
Disc area, square feet	254
Ratio projected to disc area	.29

Area of immersed midship-section, square feet	1,595
Ratio disc to immersed midship-section area	.1595
projected to immersed midship-section area	.0454
Number of tap bolts for blades	27
Diameter of tap bolts for blades, inches	4
Length of tap bolts for blades, under head, inches	7⅞
Width of longitudinal key, inches	4½
Thickness of longitudinal key, inches	2½
Length of longitudinal key, inches	40
Diameter of nut thread, inches	12
Length of nut thread, inches	10
Threads per inch	4
Immersion of upper tip of blade, inches	66
Height of lower tip above keel, inches	12

Data from Official Trial:	*Port.*	*Stbd.*
Average revolutions per minute while on course	128.5	128.4
Slip in per cent. of its own speed	19.42	19.36

Water and Oil Services.—The water-service pipe is connected to a nozzle on the main circulating pump discharge to the main condenser. This pipe leads below the floor plates to the inboard side of the main engine and has extensions to distributing manifolds placed in the housings. These manifolds are inverted brass V-castings with distributing valves to—

1 Crank pin.
2 Crank-pin oil reservoir.
3 Crosshead-pin oil reservoirs, guides and slipper.
4 Crossheads.
5 Main bearings.
6 Main bearing caps.

There is an extension from the water-service pipe to the thrust bearing, steady bearing, and stern-tube stuffing box.

On the after athwartship bulkhead is placed a small pump to supply oil to the distributing tank—on the center-line bulkhead below the berth deck.

A pipe from this tank has extensions to all the oil boxes on the main and auxiliary engines and to oil cans in the engine room. All oil boxes are arranged for sight and wick feeds. The oil pipe to the crosshead pin is connected to the water-

service pipe through a T-fitting, thus permitting water to be used with the oil, and causing it to saponify.

The crank pins are hollow, and this volume is used for an oil reservoir. Banjo oilers are fitted to transmit oil and the water service to these reservoirs.

Indicator Cards.—One set of cards from the port engine, representing average conditions, were selected for comparison with theoretical cards. These results are subject to a small correction due to the steam being admitted to the M.P. receivers during most of the trial. Card No. 4 was selected for this purpose and the comparison with the average is given below:

Port Engine.

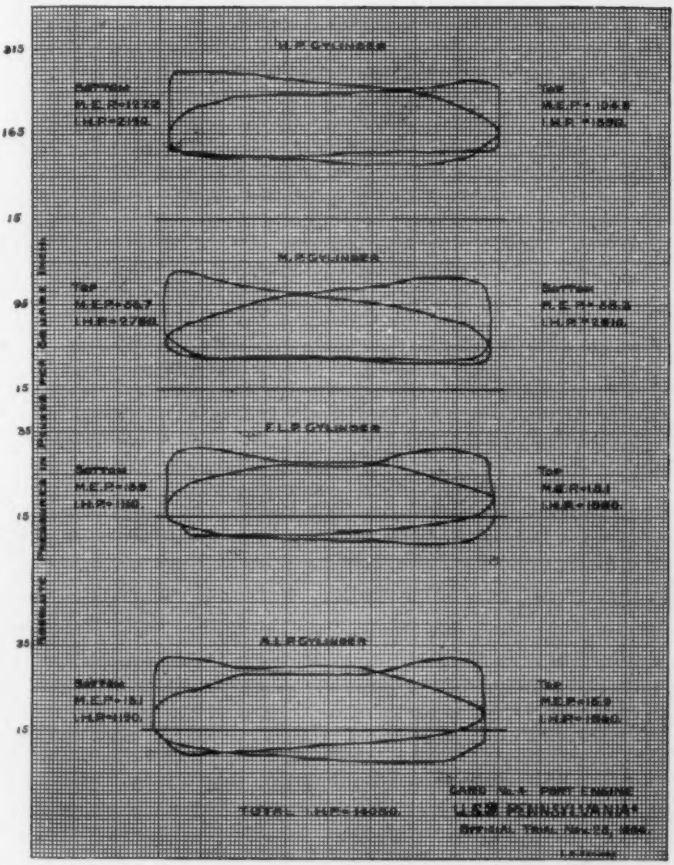
	Card No. 4. M.E.P.	Average from trial. M.E.P.
H.P. cylinder	114.50	112.64
I.P. cylinder	60.75	59.43
F.L.P. cylinder	17.65	17.39
A.L.P. cylinder	17.40	17.32

Starboard Engine.

H.P. cylinder	116.00	109.86
I.P. cylinder	57.50	55.74
F.L.P. cylinder	16.00	17.02
A.L.P. cylinder	17.00	16.04

	H.P.	I.P.	Combined F.L.P., A.L.P.	
Area of piston, top, square inches	1,164	3,167	8,302	
Ratio of areas	1	2.72	7.38	
Per cent. cut off, top	80	77	78	
bottom	77	71	72	
clearance, top	27.8	25.4	25.1	26
bottom	28.1	17.1	17.9	18

Volume at cut-off, top, H.P. cylinder, cubic inches	44,800
of clearance, top, H.P. cylinder, cubic inches	15,400
at cut-off, total, H.P. cylinder, cubic inches	60,200
bottom, H.P. cylinder, cubic inches	40,900
of clearance, bottom, H.P. cylinder, cubic inches	14,900
at cut-off, total, H.P. cylinder, cubic inches	55,800
Mean of top and bottom volumes, H.P. cylinder, cubic inches	58,000
Piston displacement + clearance, top, L.P. cylinder, cubic inches,	518,400
bottom, L.P. cylinder, cu. inches,	480,600
mean, L.P. cylinder, cu. inches,	499,500
Ratio of initial to final volumes of steam	8.62
Mean referred pressure from trial data, pounds	51.9
theoretical, pounds	91.6
Ratio of actual to theoretical	.567



INDICATOR CARDS.

BOILERS.

The Niclausse boilers installed on this ship were designed by the contractors and built by the Stirling Boiler Company. The arrangement on board ship is symmetrical with respect to the center-line bulkhead and is as follows:

Forward Compartment:

1 Battery of 4 boilers.
1 Battery of 2 boilers.

Middle Compartment:

2 Batteries of 2 boilers each.

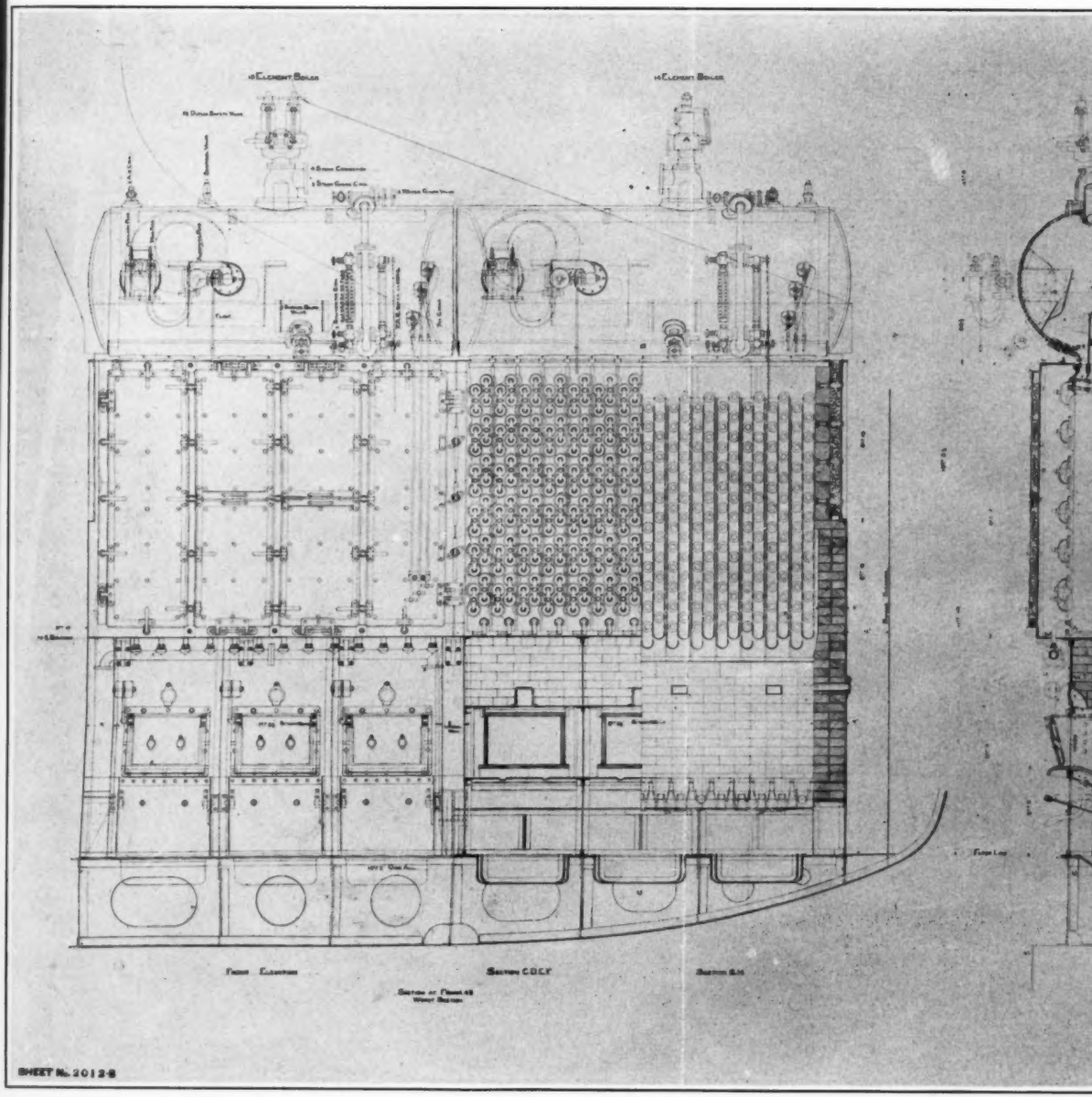
After Compartment:

1 Battery of 2 boilers.
1 Battery of 4 boilers.

The drums of these boilers are short and permit of two being placed athwartship. The heads of the drums are spherical, placed in one end convex and in the other concave. The concave ends of each pair are together. These drums are outside of the casings and do not come in contact with the heat. Below the drums are the headers, and into these are fitted the circulating and generating tubes. These tubes are supported at the other end by cast-iron plates with holes to correspond to the arrangement of tubes. A division plate in the header divides the down-current of water from the up-current containing the steam. In the generating tubes are fitted concentrically the circulating tubes. The direction of the flow of water is down the front of the headers—this side is not exposed to heat—to the circulating tubes, which are fitted closely into the division plates, and through them to the end of the generating tube, from which point it flows back to the headers and up to the drum. Tapped into the lower end of each header is a pipe to a bottom blow casting.

The baffling is obtained by placing between generating tubes steel tubes of the same length. This constrains the smoke to move athwartship but continuously upward.

The casing for the boilers is made of steel plates, stiffened



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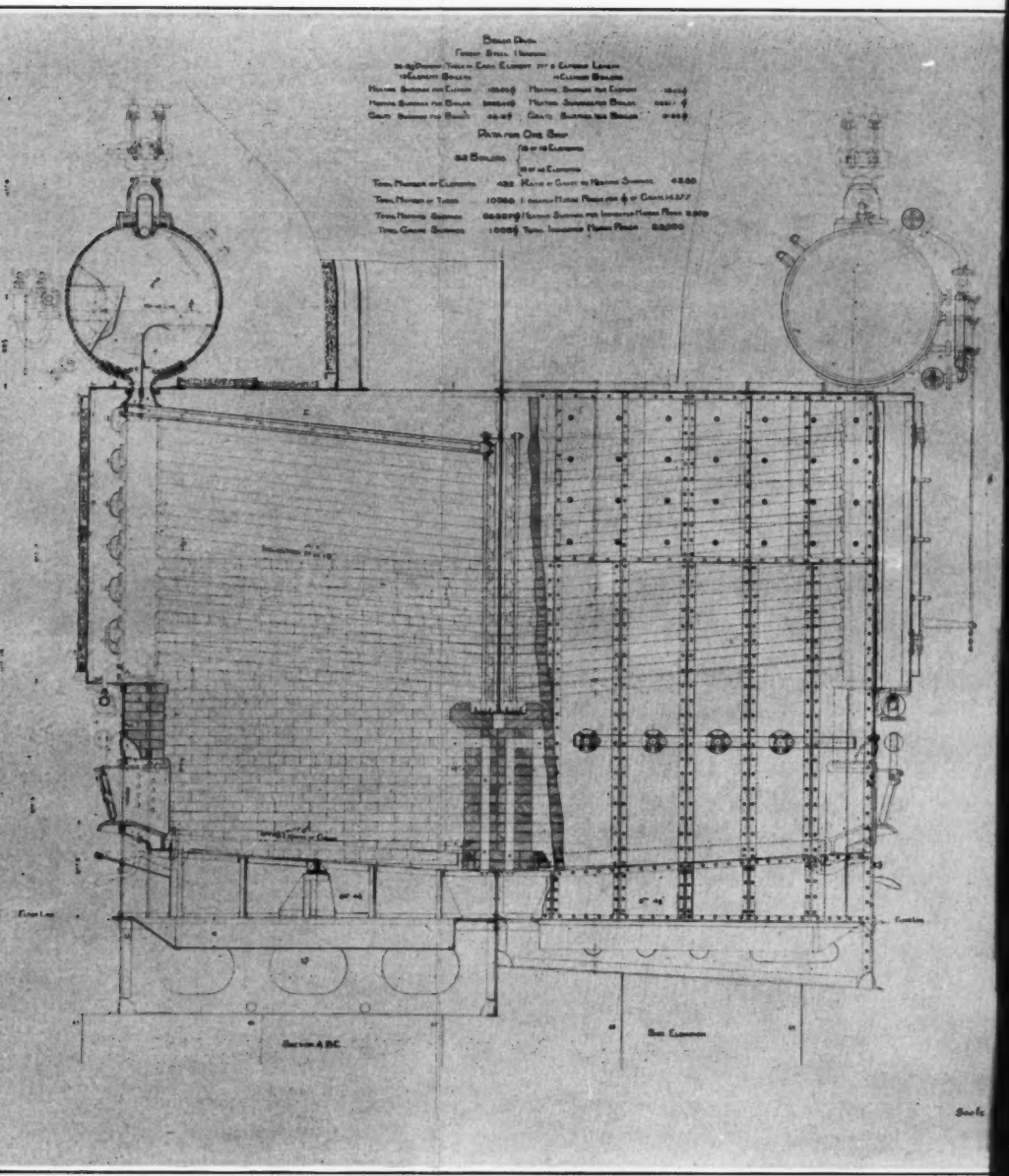
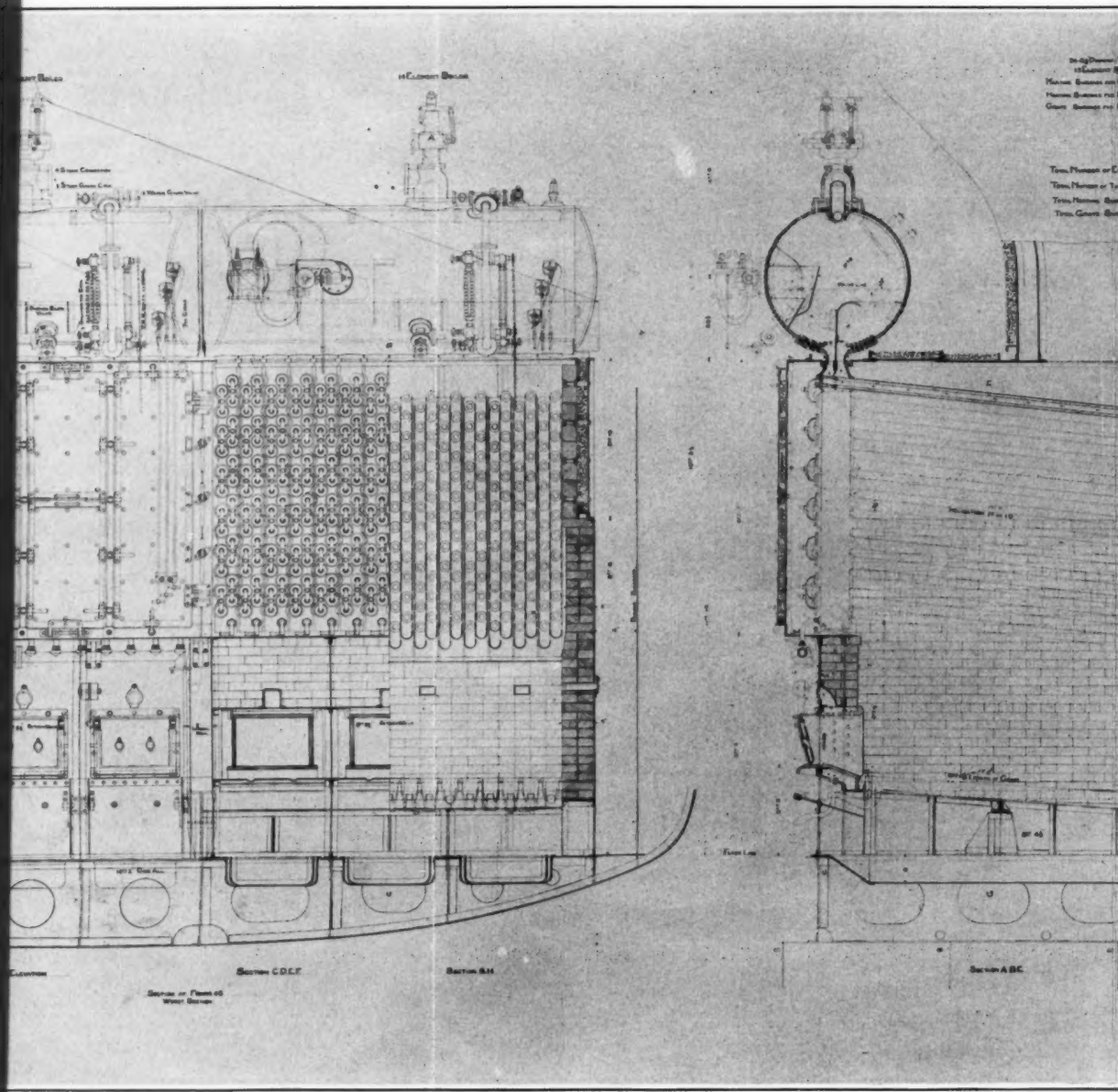
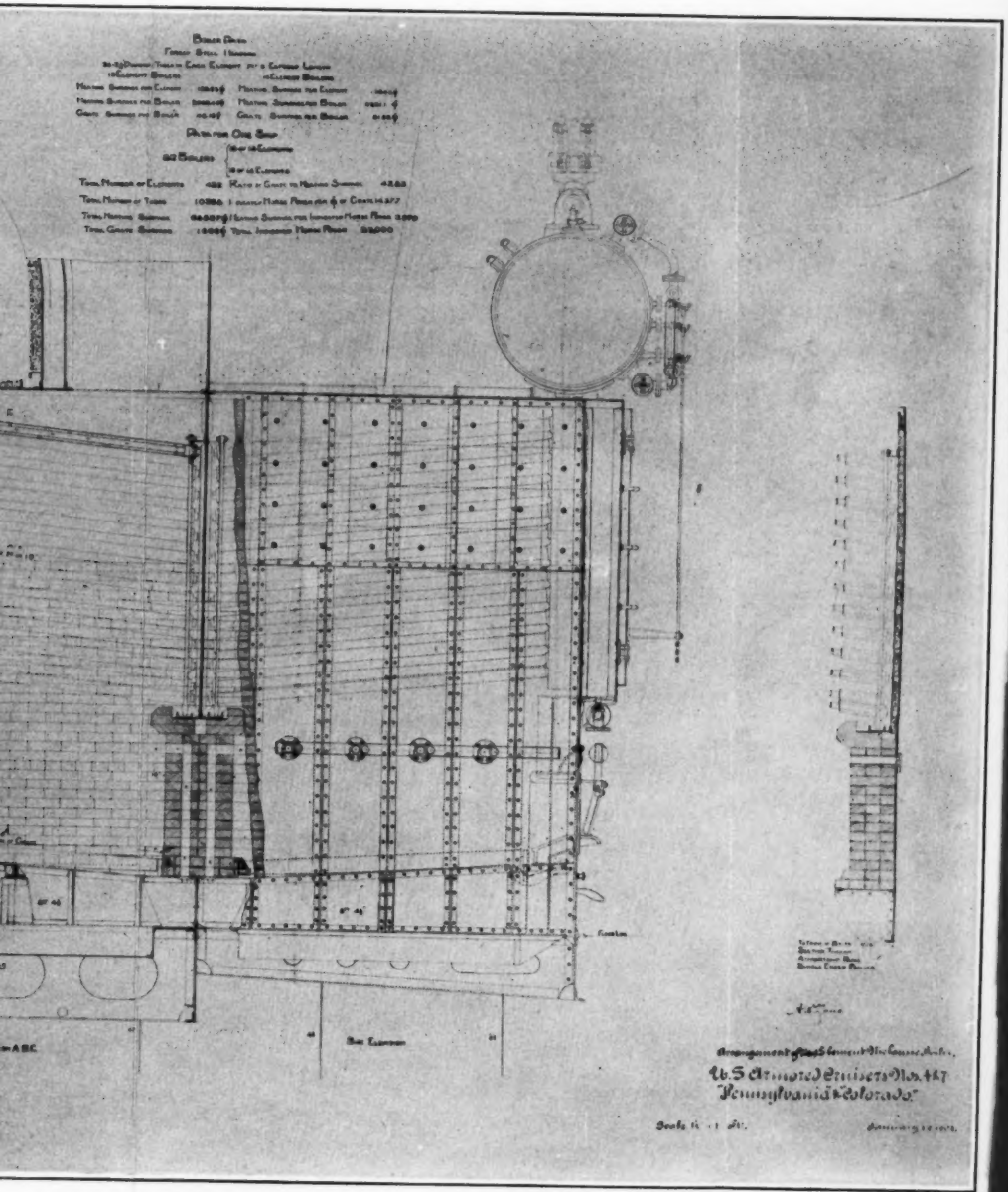


OF BOILERS, U. S. S. "PENNSYLVANIA."



ARRANGEMENT OF BOILERS, U. S. S. "PENNSYLVANIA."



NSYLVANIA."

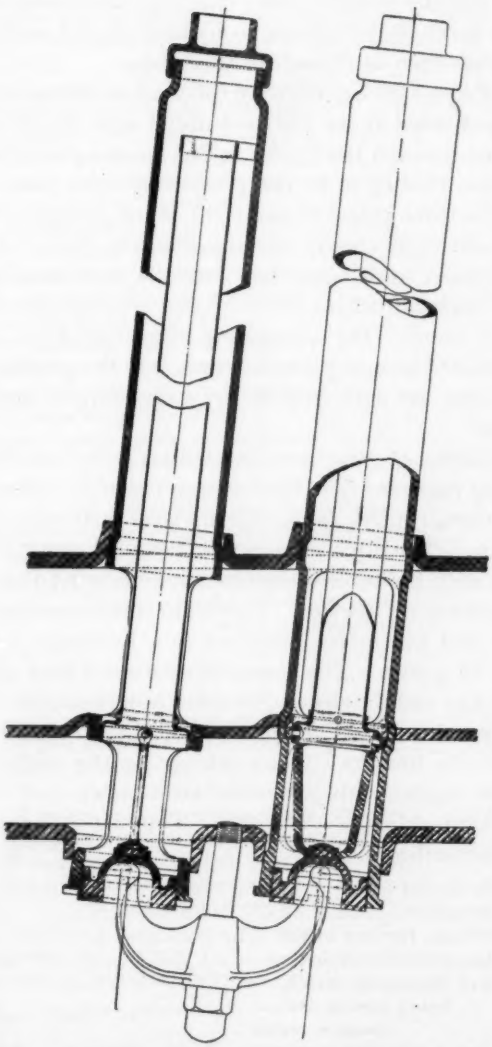
by angles. The side, back and front casings are vertical and rectangular. Fire brick and magnesia are the materials used for insulating; fire brick extends to the top of the side casings and to the tubes on the back and division casings. The furnace extends the full width of the boiler and the length of the tubes. A shaking grate of the contractors' design is installed. In the battery of two boilers there is a division wall of brick between furnaces, and in the battery of four boilers the furnaces are divided in the same manner. For each furnace there are three furnace doors, which swing on an horizontal axis, with a counterweight added to balance them, and below are three ash-pit doors similarly arranged.

A dry pipe is placed in the top of each drum, terminating in a main steam casting, also on top of drum. To this casting are bolted the safety valve and main stop valve, designed also for an emergency stop valve. The safety valve may be operated, by lifting gear, from the fireroom floor or gun deck. A sentinel valve and air cock are also on top of the drum. The feed valves are on the side of the drum, and the main and auxiliary feed-check valves are in one casting. The auxiliary feed is admitted to the feed-check valve through a valve regulated by an extension spindle from the fireroom floor. The main feed-regulating valve is operated by a float attached to a lever, and this lever is attached to the spindle of a rotating valve. The main feed passes through this valve, thence through the feed-check valve to the boiler. To the spindle of this regulating valve is attached a short lever, and from it hangs a rod to be used for operating the valve from the fireroom floor in case of emergency. The addition of weights to this rod decreases the immersion of the float and permits of changing the steaming water level. Two water-gauge columns are installed; one is the ordinary cylindrical glass and the other the Klinger reflex water gauge. These are on each side of a composition casting connected at the lower end to a valve on the drum and at the upper end by a short piece of copper pipe to a second valve on the drum. There are also three try cocks for testing the water level. The cylindrical

glasses are fitted with quick-closing cocks operated from the fire-room floor, and reflex glasses by automatic closing cocks. The internal fittings of the drum consist of a division plate for the down and up-currents of water; this extends through the nipples to the division plates in the headers. On the division plate are placed the zincs. To prevent wide variations for the float of the feed-regulating valve, due to the ship rolling, it is partially encased in a compartment perforated at the bottom. A scum pan for the surface blow is also fitted. All rivet holes were drilled through plates held together by tack bolts. The tack-bolt holes were $\frac{1}{8}$-inch smaller than the rivet and reamed to size. The weight of headers and drum is borne by the furnace front casings.

Boiler Drums.—The shell is made of one steel plate rolled to the required diameter, and its edges do not meet except at the ends where they are riveted to the heads. The shell plate is treble-riveted between inside and outside butt straps of the same width. The outside butt strap is flanged outward from the center of the boiler and machined to receive the cone nipples from the headers, while the inside butt strap is flanged in the opposite direction. This flanging is done by forcing through the plates a circular die. The manhole is cut through the shell, and on the inside is riveted a reinforcing plate flanged inward. The heads are spherical shaped with a radius equal to the internal diameter of the drum.

Headers.—The headers are forged from seamless-drawn steel tubes. The upper end is drawn down and expanded into a flange and machined to receive the cone nipple from the drum. This cone nipple is also of steel tubing machined to taper towards each end and fit accurately into the header and drum. Four bolts connect the header and drum and are inserted from inside of the drum. The head of the bolt is conical, fitting accurately into a conical hole in the outer butt strap. The other forging processes are to square the tube; insert a cast-iron mandrel and forge to the sinuous form—the cast-iron mandrel is then broken and removed—holes for the tubes are drilled and flanged outward; a steel plate is welded into the



ARRANGEMENT OF TUBES IN HEADERS OF NICLAUSSE BOILER. UPPER TUBE SHOWN IN ELEVATION. LOWER TUBE SHOWN IN PLAN.

bottom and the division plate, machined to correspond to the sinuous form, is introduced cold into the hot header. The headers are then machined for the tubes.

The Tubes.—The generating tubes are seamless-drawn steel, and forged down at one end for a drop-forged nut in order that it may go through the header. The lantern end of the tube is upset—for threads to fit the circulating tube plug—and expanded in three places to make the joints on each side of the header and to fit closely into the division plate. The tubes are machined to fit accurately into the cone bearings of the headers, and milled out between the bearings for the circulation of water. The circulating tube is made of thin sheet steel attached to a plug which screws into the generating tube. These tubes are held in place by a drop-forged steel dog for each pair.

Installation of Boilers.—The boilers were installed in the following manner: The back casing is put in place followed by the sides, furnace fronts and division wall and filled with magnesia. The brick work is next installed, and after this the headers with the tubes assembled in them. At this time the baffling tubes are inserted. The drum is then connected to the headers and the boiler subjected to a hydraulic test of 450 pounds by gauge. The casing is then completed on top, for the uptakes, and the cleaning doors in front installed. To clean the tubes these doors are opened and a steam lance inserted between the headers. The clothing for the boiler drums is magnesia lagged with galvanized steel plates.

On board ship the 13-header boilers are inboard and the 14-header outboard.

Data for Boilers:	*13 header.*	*14 header.*
Number of boilers	16	16
Length of drum, feet and inches	8- 9¼	9- 4½
Outside diameter of drum, inches	42	42
Thickness of drum plate, inch	¾	¾
heads, convex, inch	¾	¾
concave, inches	1	1
Efficiency of plate section, per cent	76.80	76.29
rivet section, per cent	111.17	110.59
Heating surface per header and tubes, square feet	158.7	158.7

	13 header.	*14 header.*
Total heating surface, square feet	2,062	2,221
grate surface, square feet	48	52
Ratio H.S. to G.S.	42.97	42.71
Total heating surface for all boilers, square feet	68,537	
grate surface for all boilers, square feet	1,600	
Ratio total H.S. to G.S.	42.84	
Number of boilers per smoke pipe	8	
Height of smoke pipe above base line, feet	100	
Area through smoke pipe, square feet	68.4	
Ratio G.S. to stack area	5.85	
Diameter of twin safety valve, inches	2½	
Number of generating tubes per header	24	
Length of generating tubes, feet and inches	8– 1½	
Thickness of generating tubes, B.W.G.	6	
Diameter of generating tubes, outside, inches	3¼	
Length of circulating tube, feet and inches	8– 0	
Diameter of circulating tube, outside, inches	$1\frac{9}{16}$	
Thickness of circulating tube, B.W.G.	21	
Area for water through nipple, square inches	8.6	
header, square inches	14.9	
lantern, square inches	7.6	
circulating tube, square inches	1.77	
steam and water through annular space in generating tube, square inches	4.41	
steam and water through lantern, square inches	10.1	
header, square inches	26.7	
nipple, square inches	12.0	
Inclination of tubes	1 to 10	
Length over all of firerooms in ship, feet	128	
Width over all of firerooms in ship, feet	23	
Total area of floors of firerooms in ship, square feet	5,888	
Total area of floor space occupied by boilers, square feet	2,570	
Ratio of boiler F.S. to fireroom floor area	.436	
Total volume occupied by boilers, cubic feet	34,600	
of firerooms above floor plates, cubic feet	122,800	
Ratio of boiler to fireroom volume	.282	
Weight of boiler, dry, per cubic feet, pounds	53.09	
water in 13-header boiler, pounds	7,070	
14-header boiler, pounds		7,610
Total weight of water in all boilers, pounds	234,880	
Weight of boiler, wet, per cubic foot	62.91	
Ratio of weight of boilers dry to boilers wet	.88	
Data from Official Trial:		
Thickness of fires, average, inches	6 to 8	
Pounds of coal burned per hour	61,546	
per square foot of grate per hour	38.46	

	13 header.	*14 header.*
Pounds of coal burned per square foot of H.S., per hour..		.898
I.H.P. of main engines per hour.....		2.18
total I.H.P. of main and auxiliary engines, per hour.....		2.12
I.H.P. per square foot G.S., main engines.....		17.5
and auxiliaries...		18.1
H.S., main engines and auxiliaries...		.42
H.S., main engines.....		.41
Steam pressure, gauge, average, pounds.....		300.2
Average temperature at base of smoke pipe, degrees Fahrenheit.....		630
fireroom floors, degrees Fahrenheit.....		82.8
fireroom gratings, degrees Fahrenheit.....		89.7
of atmosphere, degrees Fahrenheit...		59.5
draft at base of smoke pipe, in inches of water...		— .34
air pressure in firerooms, in inches of water.....		1.17

STEAM AND EXHAUST PIPING.

The auxiliary steam pipes, one port and one starboard, are suspended from the berth deck. They are parallel to the center-line bulkhead, and extend from a distributing casting on the engine-room bulkhead to the forward fire rooms, and from here are extensions to the dynamos, to the ice machine and anchor-hoist engine through a reducing valve on the port side of the upper dynamo room. A nozzle is provided in the dynamo room for steam to forward heating system and to galley. In the firerooms are extensions to pumps, to blowers and from them to the ash-hoist engines, to fire extinguishers in bunkers, and on port side to sea chests; nozzles are provided for boiler-tube cleaners, one forward for steam to dynamo condenser pump and one on starboard side for steam to whistle. Through a reducing valve on the starboard side in the machine shop steam is supplied the evaporating plant.

The distributing casting in the engine room has three nozzles: one for a cross-connecting pipe which is connected to the main steam through a cross valve at the separator, and from this valve are extensions to the fire and bilge pump and main injection sea chest—from the separator is a bleeder to main

BOILER OF U. S. S. "PENNSYLVANIA."

condenser; the second supplies steam to the main circulating pump engine, and from this pipe is an extension to a manifold which distributes steam to the hot-well pump, to auxiliary sea chest and for boiling out condenser; the third supplies steam to the main air pump and to another distributing casting in the after end of the engine room. The latter casting distributes steam to turning engine, reversing engine, auxiliary condenser engine and on starboard side to after heating system and to steering engine through a separator located near the engine.

Steam is supplied to the auxiliary steam pipes from each pair of boilers through an angle valve bolted to a nozzle on these pipes, and on the bottom of this valve is bolted a sleeve fitting into an expansion joint at the top of an inverted T-casting. This casting rests on one of the boiler drums, and on each side are expansion joints for the steam pipes from the main steam casting of the two boilers.

The main steam pipe and auxiliary steam pipe are the same for the four forward boilers, but aft of them these pipes are separate and parallel. Steam is supplied the main steam pipe through three cross-connecting valves on the auxiliary steam pipe; one valve is located in each boiler compartment. In the starboard fireroom are extensions from the main steam pipe to the main feed pumps. On the forward bulkhead of the engine room is the main steam stop valve, which may be operated from the gun deck. Below the stop valve is the separator, and connecting this with the throttle is a short piece of pipe with an expansion joint at each end. The diameter of this pipe is $14\frac{1}{8}$ inches. Between the stop valves is a cross-connecting pipe, and an extension from this supplies steam to the M.P. and L.P. receivers.

The boiler stop valve is designed to be closed by steam pressure acting on a piston on the valve stem. Steam is applied to the piston through a valve on the opposite side of the center-line bulkhead, and is operated, by an extension spindle, from the fireroom floor. There is an extension from the auxiliary steam to these bulkhead valves.

HEATING SYSTEM.

The heating system is divided into two sections, one forward and one aft. The method for each section is to supply steam through a reducing valve to a distributing manifold. To this manifold are connected a relief valve and a steam gauge. This manifold admits steam to the several circuits, which drain to a second manifold, and through a trap to the auxiliary exhaust. The manifolds for the forward sections are in the upper port dynamo room, and for the after sections in the after end of the starboard engine room. There is an independent circuit for the steam to pantries, officers' shower baths, and heaters in their bath rooms, which also drains, through a trap, to the auxiliary exhaust.

STEAM PIPE DRAINS.

The drains from the steam pipes in the forward boiler compartments are led to a trap which discharges to the main feed tank. This trap is located on the outboard bulkhead of the firerooms on a level with the gratings, and the trap-discharge pipe is supported from this bulkhead. The discharge from the dynamo trap is to this pipe. There is one trap located as above in each boiler compartment and each is arranged to be by-passed.

In the engine room the drains from the auxiliary steam distributing casting and steam to receivers at engine discharge through a trap to the trap discharge pipe. The trap of the main steam separator and the traps of the evaporator drains also discharge into this pipe. The feed-water heater drains either to the main or auxiliary condenser. The cylinder and valve chests drain to the main condenser and the jackets to a trap which discharges to the feed tank. All drains of auxiliary cylinders are led to the auxiliary exhaust and to bilge.

EXHAUST PIPING.

The main exhaust pipes are from the L.P. cylinders to the main condenser. The auxiliary exhaust pipes are parallel to the auxiliary steam pipes through the firerooms. They are

cross connected through the dynamo rooms where they are connected to the dynamo exhaust and exhaust from the ice machine and anchor-hoist engine. In the firerooms they receive the exhaust from pumps, ash-hoist engines and blowers, and in the after firerooms are extensions to the escape pipe on after stack. A nozzle is provided in the machine shop for vapor from the evaporators.

The auxiliary exhaust in the engine rooms leads to the main and auxiliary condensers through spring relief valves. These valves are provided to produce a back pressure for the feed-water heater or L.P. receivers. At the forward end of the engine room a nozzle on the bottom of the auxiliary exhaust is for the connection to the feed-water heater. This nozzle acts as a drain for the exhaust from forward. On the port side is the exhaust from steering engine. The exhaust from the main air pump is to the main condenser or L.P. receivers, and the auxiliary exhaust may also be sent into the L.P. receivers. The joints for the steam and exhaust piping are made with corrugated copper gaskets and red lead putty. Plain flanges are used, file finished from the bolt circle towards the center of pipe and tested with a face plate; on this surface the joint is made and the remainder of the flange is filed a little lower. All pipes were tested after installation with 325 pounds of steam, and found generally to be tight, and no leaks have since developed.

The material used for flanges on all work under the cognizance of the Bureau of Steam Engineering is as follows: composition flanges on all pipes below floor plates, drop-forged steel flanges for all pipes above floor plates of 5½ inches in diameter and smaller; for larger pipes cast-steel was used except for the main and auxiliary steam lines, which are steel pipes with welded flanges. Rubber gaskets were used for all water piping.

Auxiliary Condenser.—There is one auxiliary condenser in each engine room. The tubes are vertical, and on one side of condenser is bolted the circulating engine. The impeller is on the end of the crank shaft, and rods extending down from

the crosshead are connected to the air pump. The circulating water is on the outside of the tubes.

Data for one Condenser:

Number of tubes	1,161
B.W.G. of tubes	16
Diameter of tubes, inch	⅝
Length of tubes, inches	52½
Cooling surface, square feet	759
Diameter of steam cylinder, inches	6¾
piston rod, inches	1⅝
Stroke, inches	7
Length of connecting rod, center to center, inches	14
Valve travel, inches	1⅝
Diameter of crosshead pin, inches	1½
Length of crosshead pin, inches	2¾
Diameter of crank pin, inches	2½
Length of crank pin, inches	2¼
Diameter of crank shaft, inches	2½
Length of bearings, inches	4 and 3½
Area of crosshead slipper, square inches	24
Diameter of air pump piston, inches	7½
rod, inches	1½
Diameter of impeller, inches	24
Width of tip of blades, inches	2¾

The air pump valves are rubber.

Main Condenser.—One main condenser is located on the outboard side of each engine room. The shell plating is of steel and the heads of composition. Brass tubes fitting in stuffing boxes in Muntz-metal tube sheets provide the cooling surface. In the forward head is a valve to discharge the injection water directly overboard, and zinc plates are bolted to the manhole covers.

Data for One Condenser:

Number of tubes	5,662
B.W.G. of tubes	18
Diameter of tubes, inch	⅝
Length of tubes, feet and inches	15- 8
Number of supporting plates	2
Cooling surface, square feet	14,359

Data from Trial:	*Port.*	*Starboard.*
Temperature of injection water, degrees Fahrenheit	56.6	56.6
discharge water, degrees Fahrenheit	117.2	107.8
Ratio of cooling surface to I.H.P. of main engines	1.05	1.00

The Trial Board found upon inspection, after the trial, that the condensers were perfectly tight. The packing for the tubes was inserted by a Star Condenser Packing Tool, the patent for which is held by one of the erecting engineers of the contractors. One end of the packing tape is dipped into tallow and inserted in the tube sheet; the remainder of the operation is done by the packing tool. The dry tape when brought in contact with the water will swell, assisting in making a tight joint. The condensers are clothed with hair felt and lagged with teak.

The Main Circulating Pump.—Located forward of the main condenser is the main circulating pump. This pump has three suctions—the main injection, engine-room bilge and the main drain; these suctions are designed so that only one can be open at a time. The casing and impeller of the circulating pump are composition. The capacity of this pump as required by the specifications is 15,000 gallons when making 245 revotions per minute. A test was made to determine the capacity of the pump in the following manner:

The engine-room bilge was flooded to the floor plates and the bilge injection valve opened to the pump which discharged directly overboard. An observation was made on the water level at the beginning, and at the end of the trial thirty seconds later. Several trials were made to determine the average change in water level. The revolutions of the engine were very nearly 245 per minute. The volume of water pumped out may be determined by flooding the bilge from the final to the initial water level by emptying into it a known volume of water. Indicator cards were taken during the trial. To determine whether the engine can maintain the conditions for a given time it will be necessary to connect to the main injection.

Data for Pump:

Diameter of suction nozzle, inches	21
discharge nozzle, inches	21
impeller, inches	54
Width of tip of blades, inches	5¼
Diameter of H.P. piston, inches	11

Diameter of L.P. piston, inches	19
piston rods, inches	2¾
Stroke, inches	12
Length of connecting rod, center to center, inches	27
Valve travel, inches	3½
Angular advance H.P., degrees	35
L.P., degrees	37½

	Top.	*Bottom.*
Steam lead, H.P., inch	⅛	3/16
L.P., inch	3/16	¼
Cut off, H.P	.75	.69
L.P.	.74	.67

Diameter of H.P. valve, inches	4
L.P. valve, inches	9
Diameter of crosshead pin, inches	4
Length of crosshead pin, inches	5½
Diameter of crank pin, inches	5½
Length of crank pin, inches	6½
Diameter of crank shaft, inches	5½
Lengths of bearings, inches	10, 10, 6½
Crank angle, degrees	90
Area of crosshead slipper, square inches	74
Data from Test:	
Revolutions per minute	246
I.H.P.	249
Rate of discharge in gallons per minute	18,000

Data from Official Trial:	*Port*	*Starboard.*
Average revolutions per minute	166.5	213.6
Average I.H.P.	92.2	155 9

Main Air Pumps.—Aft of the main condensers are installed the main air pumps. These are twin vertical-beam air pumps of the Blake design. The air pump discharges into the filter and feed tank in after end of engine room.

Data for Pump:

Diameter of steam cylinders, each, inches	14
water cylinders, each, inches	35
Stroke, inches	18
Diameter of steam piston rod, inches	2¾
air piston rod, inches	3½
suction nozzle, inches	13
discharge nozzle, inches	11

The air-pump valves are phosphor-bronze discs.

Data from Official Trial:	*Port.*	*Starboard.*
Average strokes, per minute	22.80	23.10
vacuum, inches	26.00	26.66
indicated horsepower	18.74	17.27

FEED SYSTEM.

Feed and Filter Tank.—The top of the feed tank is arranged as a filter, and the filtering material is "loofa." This is placed between horizontal perforated plates. The filtering chamber is divided by vertical divisions so that the water flows from the bottom of one to the top of the succeeding one.

Below the filtering chamber is the feed tank. All material is steel plates and angles, and is galvanized. The clothing is hair-felt lagged with galvanized steel plates.

Capacity of each feed and filter tank, cubic feet, 711.

Capacity of reserve feed tanks, inner bottom,

	Cubic feet.
B, 87	634.1
B, 88	634.1
B, 89	619.0
B, 90	619.0
B, 91	589.8
B, 92	589.8
B, 93	942.8
B, 94	942.8
B, 95	942.8
B, 96	942.8
B, 97	937.7
B, 98	937.8
B, 99	2,224.6
	11,557

Hotwell Pumps.—The hotwell pumps are placed beneath the main condensers. They are 12 inches by 16 inches by 16 inches, horizontal, simplex, piston pumps, of Blake design. The suction manifold has the following valves:

1. From either filter and feed tank.
2. From either air-pump channel way.
3. From reserve feed tanks.
4. From water-boat filling pipe.

The discharge manifold:

1. To filter and feed tank.
2. To reserve feed tanks.
3. To feed system.

Data from Official Trial:

Average strokes of port pump	18.5
starboard pump	18.5
indicated horsepower	18.2

The discharge to the feed system is through a grease extractor and a feed heater, located on the forward athwartship bulkhead, one of each port and starboard. Each of these may be by-passed.

Turkish toweling is used for filtering material in the grease extractors. This is drawn over perforated brass tubes. The feed-water heater has a nozzle on the side to admit the auxiliary exhaust steam, and drains to the main or auxiliary condenser. The feed water is admitted at the bottom, and after passing through the tubes it is discharged at the top to the main feed pump suction.

Data for One Heater:

Number of tubes	832
B. W. G. of tubes	18
Diameter of tubes, inches	$\frac{5}{8}$
Length of tubes, feet and inches	7- $2\frac{1}{2}$
Area of heating surface (tubes), square feet	952
(tube sheet), square feet	3
total, square feet	955

Data from Official Trial:	*Port.*	*Stbd.*
Average temperature of water to feed heater, degrees Fahrenheit..	85.7	80.4
from feed heater, deg. Fahrenheit..	150.2	148.5

Grease extractor by-passed.

The feed-water pipes from the heaters pass forward into the firerooms and meet on the center-line bulkhead extending forward on the starboard side above the main feed pumps. There are extensions from it down to the four 12-inch by $7\frac{5}{8}$-inch by 12-inch vertical, duplex, center-packed plunger, Blake design, main feed pumps. These pumps discharge to a feed main below and parallel to the feed-supply pipe; from this pipe are extensions to the starboard boilers and through the center-line bulkhead to the port boilers.

Data from Official Trial:

Average double strokes per minute of all pumps	37.2
Total indicated horsepower	310
Average pressure maintained in feed main, pounds	357

On the port side of the center-line bulkhead opposite the main feed pumps are the auxiliary feed pumps, of the same dimensions and design. The suction manifold has the following valves:

1. Suction from sea.
2. Suction from auxiliary drain.
3. Suction from boilers.
4. Suction from main or reserve feed tanks.
5. Suction for hose connection.

The discharge manifold:

1. Discharge overboard.
2. Discharge to fire main.
3. Discharge to auxiliary feed system.
4. Discharge for hose connection.

There are extensions from the auxiliary feed main to the port boilers, and through the center-line bulkhead to the starboard boilers.

One of these pumps was in constant operation during the official trial and averaged about ten double strokes per minute, maintaining a pressure of about 425 pounds in auxiliary feed line. The pump discharged through its relief valve.

BLOWERS.

The fireroom blowers, manufactured by the B. F. Sturtevant Co., are located on the berth deck near the center-line bulkhead and discharge directly into the firerooms. A trunk extends from the blower room to the main deck for the supply of air.

In each blower room is located the air lock to the firerooms. To establish communication with the firerooms, a voice pipe is installed. The arrangement of the blowers is symmetrical

with respect to the center-line bulkhead, and is as follows, beginning forward:

1 blower for single fireroom.
2 blowers for double firerooms.
2 blowers for double firerooms.
2 blowers for double firerooms.
1 blower for single fireroom.

Data for One Blower:

Diameter of fan, inches	60
Width of tip of blades, inches	18
Area of induction nozzle, square inches	1,280
eduction nozzle, square inches	1,580
Number of cylinders	2
Diameter of cylinder, inches	5
piston rod, inches	$1\frac{1}{8}$
Stroke, inches	4
Valve travel, inches	$2\frac{1}{4}$
Length of connecting rod between centers, inches	12
crosshead pin, inches	$2\frac{1}{4}$
Diameter of crosshead pin, inches	$1\frac{3}{4}$
Length of crank pin, inches	$3\frac{1}{2}$
Diameter of crank pin, inches	3
Area of crosshead slipper, square inches	8
Diameter of crank shaft, inches	$2\frac{15}{16}$
Length of bearings, inches	$6\frac{3}{8}$
Crank angle, degrees	180
Number of blowers on ship	16
blower rooms	10

Data from Official Trial:

Revolutions per minute	500
Air pressure in fireroom	1.17
I.H.P. for one blower	21.9
sixteen blowers	350

ASH HOISTS.

The arrangement of the fireroom ventilators corresponds to the arrangement of blower rooms. The ash-hoist engines are located in the air trunks for the blowers, and are bolted to the ventilator casing. Inside the ventilator shaft guides are placed for the ash buckets. There is an opening on the gun deck for discharging ashes, and in the forward ventilator shafts

is an additional opening on the boat deck for supplying coal to the launches.

The engine is operated by a follow-up gear from the gun deck. On the test made the engines hoisted 300 pounds from the fireroom floor to the gun deck in five seconds with 80 pounds of steam. Under the main deck is placed a trolley track to facilitate transporting ashes to the ash chutes. On the port side are located three of the ash chutes and the other three are on the starboard side.

Data for One Engine:

Number of cylinders	2
Diameter of cylinder, inches	4½
of piston rod, inches	1
Stroke, inches	4½
Valve travel, inches	1½
Length of connecting rod between centers, inches	10
crosshead pin, inches	1½
Diameter of crosshead pin, inch	1
Length of crank pin, inches	1½
Diameter of crank pin, inches	1¾
Area of crosshead slipper, square inches	11
Diameter of crank shaft, inches	2
Length of bearing, inches	3½
Crank angle, degrees	90
Diameter of drum, inches	5
Length of drum, inches	10
Number of ash-hoist engines	10

EVAPORATING PLANT.

The evaporating plant is arranged with two evaporators, the pumps and fresh-water tank on the berth deck. On the gun deck, directly above, are the other two evaporators and filters. In the ventilating trunk the three distillers are placed vertically.

Evaporators.—The shells and heads are of plate steel. The heads are supported by stay bolts and I bars riveted to them. Brass tubes expanded into composition headers provide the heating surface. The passage of the steam is from the front to the back header through all the tubes except the bottom row, through which it is returned to the front header. Steam gauge, relief valve and drain connections are made to the front

header. A trap, which discharges to the feed tank, is provided to drain each evaporator.

Distillers.—These are the Navy Department design. The bodies are of cast iron and the cooling surface is obtained from brass tubes, tinned inside and out, and expanded into brass tube sheets. Expansion is provided for by bolting a casting with a nozzle to the upper tube sheet. This nozzle goes through a stuffing box at top of distiller. The circulating water passes through the tubes and out at the nozzle.

Pumps.—The distiller circulating water is supplied by a 12-inch by 16-inch by 16-inch horizontal, simplex, piston pump. This pump may discharge to the sanitary system or to the fire main. The evaporator feed is supplied by a 4½-inch by 5-inch by 6-inch vertical simplex pump; its suction is from the discharge pipe for the distiller circulating water. The fresh and salt-water pump is of the vertical, simplex type and of the following dimensions: 6 inches by 5 inches by 4 inches by 6 inches. The cylinders are arranged with the steam at the top, below it the fresh water, and the salt water at the bottom. All pumps are of the Blake design.

Piping.—Each evaporator receives steam through a reducing valve on the auxiliary steam line. The vapor may be sent to the distillers, to the auxiliary exhaust or to operate the evaporators in "double effect." From the distillers the fresh water passes through the filters to the fresh-water tank, from which it is pumped to the distributing tank, or drains to the reserve feed tanks.

A test was made during the run from New York to Boston to determine the capacity of the plant. The specifications require that the evaporators shall have a combined capacity of 23,000 gallons of potable water per twenty-four hours, and the distillers to have a combined capacity of 10,000 gallons of potable water per twenty-four hours. Two evaporators were used for this test and all three distillers. The discharge nozzle of each distiller was tapped to permit testing the distilled water with the silver-nitrate solution. The filtering material was removed from the two filter tanks,

and these were filled alternately with the distilled water. A record was made of the number of times these tanks were filled. The evaporator, feed, and fresh and salt-water pumps were in constant operation, maintaining an average hydrometer test of $\frac{3}{32}$ at a temperature of 190 degrees Fahrenheit. The following data was obtained:

EVAPORATORS.

Data for One Evaporator:	
Heating surface (tubes only), square feet	290
(headers only), square feet	33
total, square feet	323
Gallons of water evaporated in 24 hours	7,500
Gallons of water evaporated per square foot of tube-heating surface in 24 hours	25.9
Gallons of water evaporated per square foot of total heating surface in 24 hours	23.2
Gallons of water evaporated per 24 hours for four evaporators	30,000

DISTILLERS.

Data for One Distiller:	
Cooling surface (tubes only), square feet	66
(tube sheets only), square feet	2.2
total, square feet	68.2
Gallons of water distilled in 24 hours	5,000
Gallons of water distilled per square foot of cooling surface in 24 hours	73.3
Gallons of water distilled per 24 hours for three distillers	15,000
Data from Observations (Averages):	
Temperature of injection water, degrees Fahrenheit	49
discharge water, degrees Fahrenheit	74
room, initial at 8 P. M., degrees Fahrenheit	88
final at 2 A. M., degrees Fahrenheit	63
Strokes of circulating pump per minute	36

REFRIGERATING PLANT.

The refrigerating plant is located on the port side of the berth deck forward. The refrigerator rooms are divided into five compartments, and are insulated with cork, lined on the inside with zinc, except the floors, which are covered with sheet lead. Above, on the gun deck, are located the two scuttle butts.

The ice machine is of the Allen dense-air type, designed for a cooling effect equivalent to three tons of ice per twenty-four

hours. The piping for the cooling air is arranged so that it may be sent through the refrigerator rooms and returned to the machine, or it may be sent through the scuttle butts before returning to the machine. It may also be by-passed through the ice tank before it goes to the refrigerator rooms.

When the test for this plant was made the cooling air was sent through the ice tank, thence to the refrigerator rooms and to the scuttle butts. At the start the temperature of the water in the ice tank was 49 degrees Fahrenheit, and in two hours and twenty minutes six cakes of ice had been made. At this time the three cakes at the end, where the cooling air is exhausted, were not completely frozen, so their positions were exchanged with the three middle cakes, and were completely frozen thirty minutes later. The temperature of the water put into the scuttle butts was noted, and also at the end of thirty minutes when seventeen gallons were drawn from each. Afterward the scuttle butts were refilled, and this operation repeated every thirty minutes during the test. At the end of one hour the number of gallons drawn off was increased to twenty-three.

The following are the averages of the data obtained at the end of four hours:

Temperature of the water to be frozen, degrees Fahrenheit	49
Pounds of ice in 24 hours	1,080
Temperature of water put into scuttle butts, degrees Fahrenheit	56
drawn off scuttle butts, degrees Fahrenheit	39
Number of gallons drawn off in 24 hours	2,200
Temperature of room, degrees Fahrenheit	65
atmosphere, degrees Fahrenheit	46
injection water, degrees Fahrenheit	51
ICE MACHINE.	
Steam pressure, pounds	235
Compression cylinder, pounds	241
Expansion cylinder, pounds	64
Revolutions per minute	108
REFRIGERATOR ROOMS.	
Temperature entrance, initial, degrees Fahrenheit	54
final, degrees Fahrenheit	50
Junior officers' room, initial, degrees Fahrenheit	40
final, degrees Fahrenheit	1
Ward room, initial, degrees Fahrenheit	51

Ward room, final, degrees Fahrenheit	10
Captain's room, initial, degrees Fahrenheit	48
final, degrees Fahrenheit	—2
Crew, initial, degrees Fahrenheit	48
final, degrees Fahrenheit	17
Ice Machine Data:	
Diameter, steam cylinder, inches	10
compression cylinder, inches	9
expansion cylinder, inches	7½
piston rods, inches	2
Stroke, inches	7
Length of connecting rod, center to center, inches	33

ELECTRIC PLANT.

The electric plant is located below the berth deck and forward of the firerooms. It extends the full width of the firerooms and is divided into an upper and lower dynamo room. The center-line bulkhead passes through each, and an archway through it provides communication between port and starboard sides. The General Electric marine generating sets are installed. In the lower dynamo room are located:

Starboard: 1 100-kw. marine generating set.
1 50-kw. marine generating set.
1 dynamo condenser.
1 exhaust separator.
1 steam trap for separator.
Port: 2 100-kw. marine generating sets.

In the upper dynamo room are located:

Starboard: 2 50-kw. marine generating sets.
1 switchboard.
1 steam separator.
Port: 1 50-kw. marine generating set.
1 steam separator.
1 switchboard for searchlights.
1 central communicating room.

Piping.—Steam is supplied on each side of the ship and passes through a separator and a reducing valve to a distributing manifold. There is a pipe cross connecting these mani-

folds and another to the lower dynamo room. The engines exhaust to the dynamo condenser, or to the auxiliary exhaust to the engine room or the atmosphere. The separators drain to a trap which discharges to the main feed tank, and the cylinder drains discharge to the dynamo condenser or exhaust separator. The dynamo exhaust drain, for use when exhausting to the atmosphere, also discharges to the exhaust separator. A 2-inch by 1¼-inch by 2¾-inch pump is provided to keep this separator drained, and discharges to the main feed tank. The dynamo condenser air pump discharges to the main feed tank in the starboard engine room.

Data for Condenser:	
B.W.G. of tubes	18
Number of tubes	1,001
Diameter of tubes, inch	⅝
Length of tubes, feet and inches	7- 8
Cooling surface, square feet	1,228
Horizontal combined air and circulating pump, inches	12 × 14 × 14 × 12

Data for Electric Sets:	*100 kw.*	*50 kw.*
Diameter of H.P. piston, inches	10	7½
L.P. piston, inches	18	14
piston rod, inches	2¼	1¾
Stroke, inches	10	8

SYSTEM OF WIRING.

The cables from each generator are led to the switchboard and bus-bars connect this board to distributing panels. The distributing panels for light and power are separate. By this means the output of any generator may be sent to the light-distributing panel or to the power-distributing panel, or any number of machines may be so used. A special distributing panel is installed for the searchlights, and the output of any generator may be sent to it.

MACHINE SHOP.

The machine shop is located beneath the berth deck and between the engine and fire rooms. It extends the full width of the engine rooms and is entered from the first grating in each engine room. An archway in the center-line bulkhead

provides communication between the port and starboard sides. The following machines are installed:

1 30-inch swing extension gap lathe.
1 14-inch swing screw-cutting lathe.
1 16-inch crank shaper.
1 16-inch drill press.
1 12-inch two-wheel emery grinder.
1 16-inch sensitive drill.
1 30-inch grindstone.
1 combined hand punch and shears.
1 universal milling machine.

These tools are provided with the requisite attachments. Lockers are provided, also tool benches, and for the indicators two lockers are provided, one port and one starboard. The machines are driven by a motor located on the athwartship bulkhead. A test was made to ascertain if this motor was sufficiently powerful for the work to be required of it. In each tool a piece of steel was placed and the machine run at its heaviest cut. The emery wheels and grindstone were given a load by grinding a piece of steel. These operations occurred simultaneously and were maintained for one half hour.

The following data was obtained:

Volts, average	126
Ampères, average	23
Revolutions per minute	608
Electrical horsepower, input	3.9

BUILDERS' TEST OF MOTOR.

Electrical horsepower, input	17.1
output	14.5
Ratio	.85

THE OFFICIAL TRIAL.

The U. S. S. *Pennsylvania* left her anchorage in Boston harbor at 6·50 A. M., November 23, 1904, for the Cape Ann trial course. On her way out the forced-draft blowers were started, the boiler pressure increased and the main engines gradually worked up to full power. The ship was steered directly for the course, and, by 75th meridian time,

	Hr.	*Min*	*Sec.*
Passed the first stake boat, north, A. M.	8	52	11
last stake boat, north, A. M.	10	51	34
Time required for turn	0	11	57.5
Passed the first stake boat, south, A. M.	11	3	31.5
last stake boat, south, M.	12	59	37.5
Length of trial course in nautical miles			44.019
Corrected speed for the run north, knots per hour			22.300
south, knots per hour			22.575
Mean corrected speed			22.436

After passing the last stake boat the engines were gradually slowed down to 120 revolutions per minute for maneuvering the ship. The time required to put the helm from hard-a-starboard to hard-a-port was 20.5 seconds, and from hard-a-port to hard-a-starboard was 18 seconds. During this test the maximum angle of heel observed was 4.5 degrees. When the engines had been slowed down to 110 revolutions per minute they were stopped and reversed to full speed astern—the forced-draft blowers had in the meantime been stopped—and the time elapsed from the stopping of the engines until the ship was still in the water was two minutes and two seconds.

The draught of the U. S. S. *Pennsylvania*, taken while at anchor on the morning of the trial, was:

Forward, feet and inches,	24– 1.5
Aft, feet and inches,	24– 5.8
Mean, feet and inches,	24– 3.6
After the run:	
Forward, feet and inches,	23– 8.9
Aft, feet and inches,	24– 0.5
Mean, feet and inches,	23–10.7
corrected, feet and inches,	23–11.8

THE ENGINE ROOM.

The main engines during the trial ran with very little vibration and none of the bearings heated. The water service was used in the main bearings, crosshead guides and thrust bearings, but very little was used on the crank pin or crosshead bearings. The main circulating and air pumps worked

smoothly. The maximum pressure permitted in the H.P. valve chest was 250 pounds by gauge, and during the entire trial the throttle valve was never more than .30 open.

Data from Trial:	*Port.*	*Starboard.*
Steam pressure at throttle, gauge	278.5	280.
in fireroom, gauge	300.2	300.2
H.P. valve chest, gauge	250.	250.3
M.P. receiver, gauge	107.5	114.4
L.P. receiver, gauge	23.3	23.9
Vacuum, inches	26	26.7
Position of links	Full gear.	
Temperature of atmosphere, degrees Fahrenheit	59.5	59.5
at floor plates	70.1	68.6
first grating	83.2	82.8
Total number of revolutions on run north	15,230	15,113
south	14,970	15,053
while on course	30,200	30,116
Average revolutions per minute, north	127.98	127.00
south	129.07	129.77
while on course	128.53	128.38
Indicated horsepower of main engines	14,336.4	13,669.7
total	28,006.1	

THE FIREROOMS.

It was desired for this trial that the coal consumption be accurately determined, and for this purpose the coal had been put in bags of 100 pounds each. The coal used was hand-picked Pocahontas. Permission was granted to set the safety valves at 315 pounds, but the pressure in the boilers was to average 300 pounds, the designed working pressure. This arrangement was to save feed water, because on her sister ship, the U. S. S. *Colorado*, the safety valves—set at 300 pounds—were lifting continuously throughout the trial, and this would materially affect the coal-consumption figures. In order to facilitate firing the furnaces they were numbered from left to right: 1, 3, 5, 2, 4 and 6. This would make number 1 furnace on opposite corners in the double firerooms and give the men ample room in which to work. An apprentice boy was provided with a watch, and instructed at what time intervals the furnaces were to be fired. At the termination of each interval the boy called the number of the furnace to be fired—

these numbers were called consecutively. By this method the boilers were fired alternately. The time interval was one, two and three minutes, varying with the steam pressure, and in one of the firerooms the interval was six and even twelve minutes.

The forced-draft blowers were maintained at 500 revolutions per minute, except at the beginning of the trial when they slowed down to 300 for a short time. But it was decided to regulate the draft by the ash-pit doors, and the blowers were run at 500 revolutions per minute for the remainder of the trial. In one of the firerooms the ash-pit doors were closed the greater part of the trial, and closed at intervals in all of them. The thickness of the fires was about 6 to 8 inches and the coal was spread evenly over the fires.

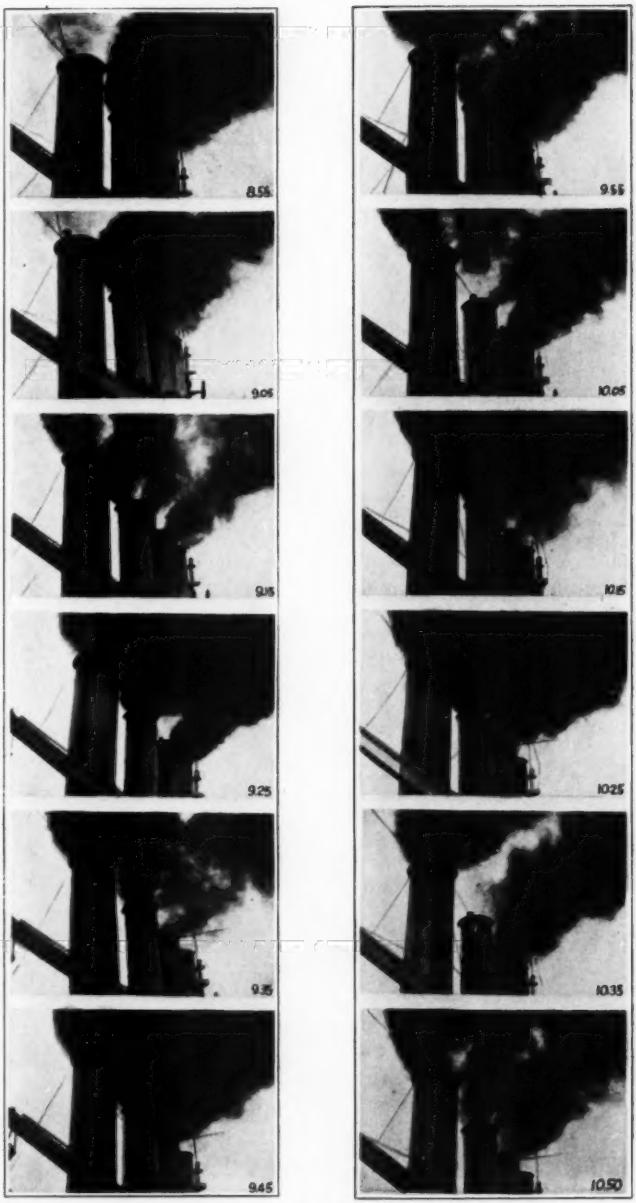
The number of men in the fireroom was as follows:

Double firerooms:	Single firerooms:
1 Water tender.	1 Water tender.
4 Firemen.	2 Firemen.
2 Coal passers in fireroom.	1 Coal passer in fireroom.
2 Coal passers in bunker.	2 Coal passers in bunker.
1 Apprentice boy.	1 Apprentice boy.

The automatic feed-regulating valves worked almost without attention and in some firerooms were not touched during the trial. During the trial photographs were taken every 10 minutes of the smoke emitted from the smoke pipes. The color of the smoke was a dull brown to gray, and not unusually heavy. The temperature at base of smoke pipe did not at any time exceed 640 degrees Fahrenheit.

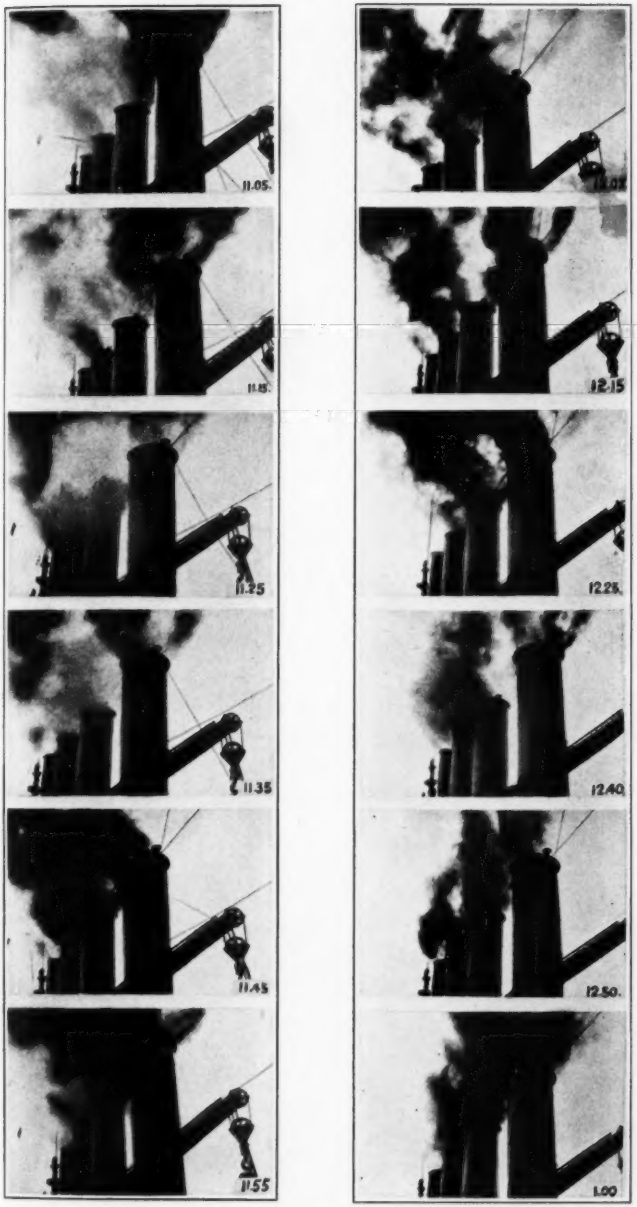
Data from Official Trial:

Forced-draft blower R.P.M., average	500
Air pressure, inches of water, average	1.17
Draft at base of smoke pipe, inches of water, average	—.34
Temperature at base of smoke pipe, average, degrees Fahrenheit	630
Thickness of fire, inches, average	6 to 8
Steam pressure, gauge, average	300.2
in port engine room, gauge, average	278.5
starboard engine room, gauge, average	280.0
port H.P. valve chest, average	250.0
starboard H.P. valve chest, average	250.3



U. S. S. "PENNSYLVANIA."

Photographs of Smoke taken at ten-minute intervals during trial. Run North (Cape Ann towards Cape Porpoise).



U. S. S. "PENNSYLVANIA."

Photographs of Smoke taken at ten-minute intervals during trial. Run South (Cape Porpoise towards Cape Ann).

INSPECTION AFTER TRIAL.

Main engine cylinders, valve chests, low-pressure valves, crank and crosshead-pin bearings, crank-shaft bearings and crosshead guides were examined and found to be in excellent condition. The condensers and feed-water heaters were found to be tight and free from grease. The main air pumps, feed tanks, auxiliary condensers and pumps were free from grease and in good condition. The boilers, grates and brickwork were found to be in excellent condition. Some of the tubes in the lower rows were found to be bowed up from $\frac{1}{16}$-inch to $\frac{5}{16}$-inch, but generally were found to be in a normal condition. Several tubes were removed and no difficulty was encountered in removing them. The time required to remove a circulating tube was 58 seconds and a generating tube 1 minute and 3 seconds, or a total of 2 minutes and 1 second. The tubes were found to be in excellent condition.

NEW ENGINEERING AND NAVAL CONSTRUCTION BUILDING, U. S. NAVAL ACADEMY.

By JOHN K. BARTON, COMMANDER, U. S. N.,

Head of Department of Engineering and Naval Construction, Naval Academy.

While the changes in the course of instruction at the Naval Academy, made necessary by the Personnel Law of 1899, have been watched with eager interest by the professional world both at home and abroad, none the less has been the interest displayed over the building operations in the transition from the old to the new and modern Academy, a work made necessary in order to accommodate the great increase in the number of midshipmen, together with the installation of apparatus, tools and machinery for their education.

By most of the members of the American Society of Naval Engineers and the readers of the JOURNAL, the removal of the old Steam Building of 1866, a tinge of regret may be felt at the disappearance of an old land mark, yet the transition to the commodious and roomy structure of the Engineering and Naval Construction building of 1904, with its facilities, roomy space and modern appliances, is the culmination of a hope that has been looked forward to for many years.

The cramped and restricted area of the old Steam Building has been felt severely, even with the limited number of students of a few years ago, averaging about 300, a number hardly exceeding the fourth class of today, while the entire number now under instruction in all classes is 825. With the entry of the class in June next the entire number of midshipmen will amount to nearly a thousand, which will probably be the maximum number in any one year.

With this large increase in prospect the design of the engineering building was executed, and as constructed has a

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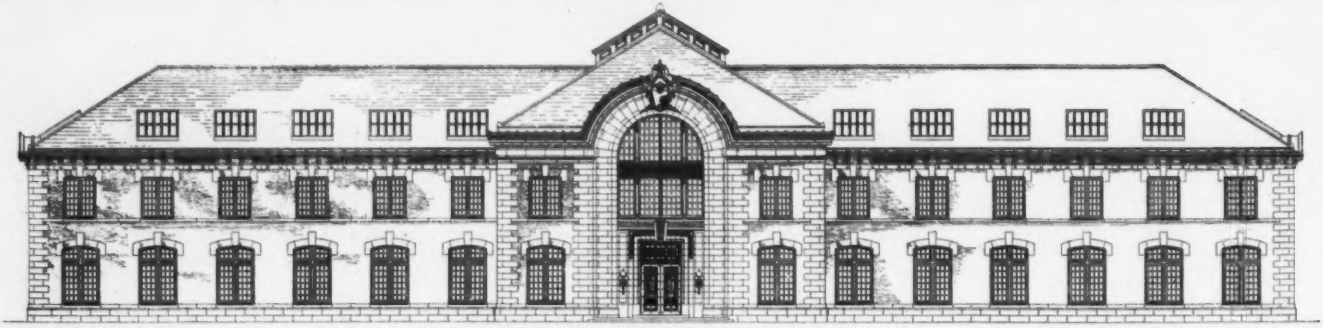

MARINE ENGINEERING AND NAVAL CONSTRUCTION BUILDING.

U.S. NAVAL ACADEMY, ANNAPOLIS, MD.

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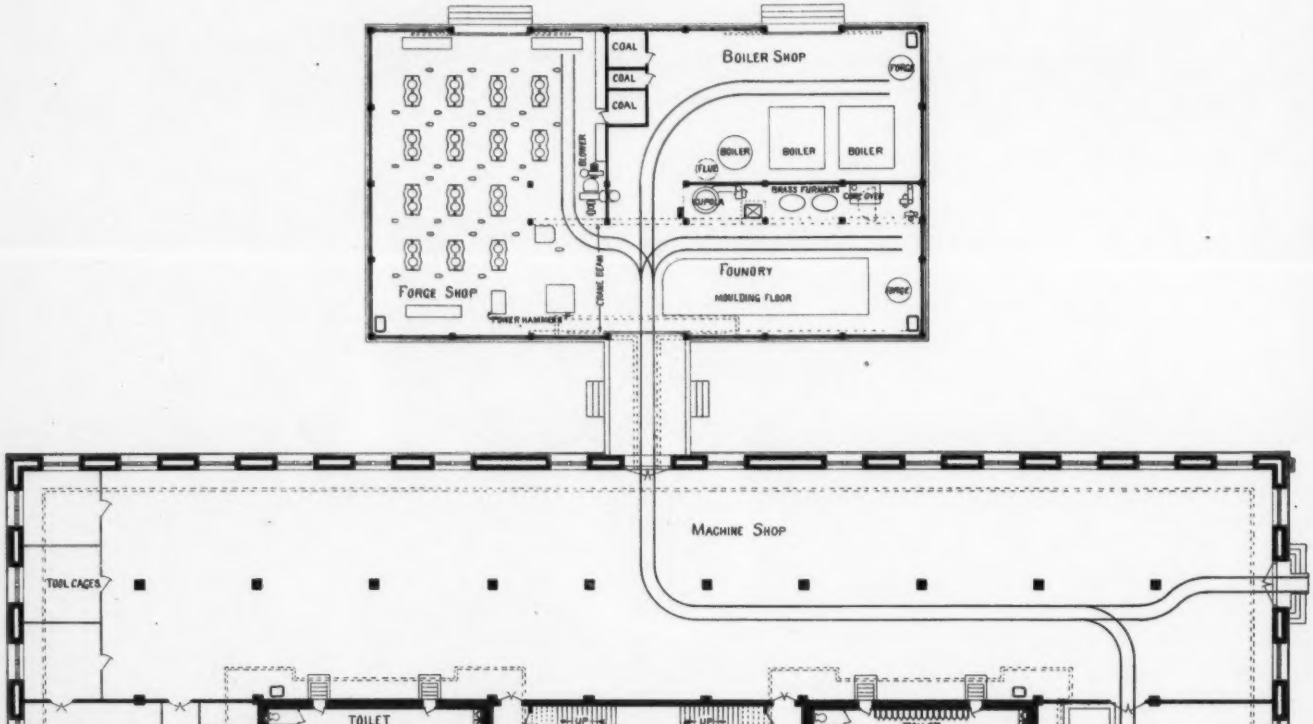
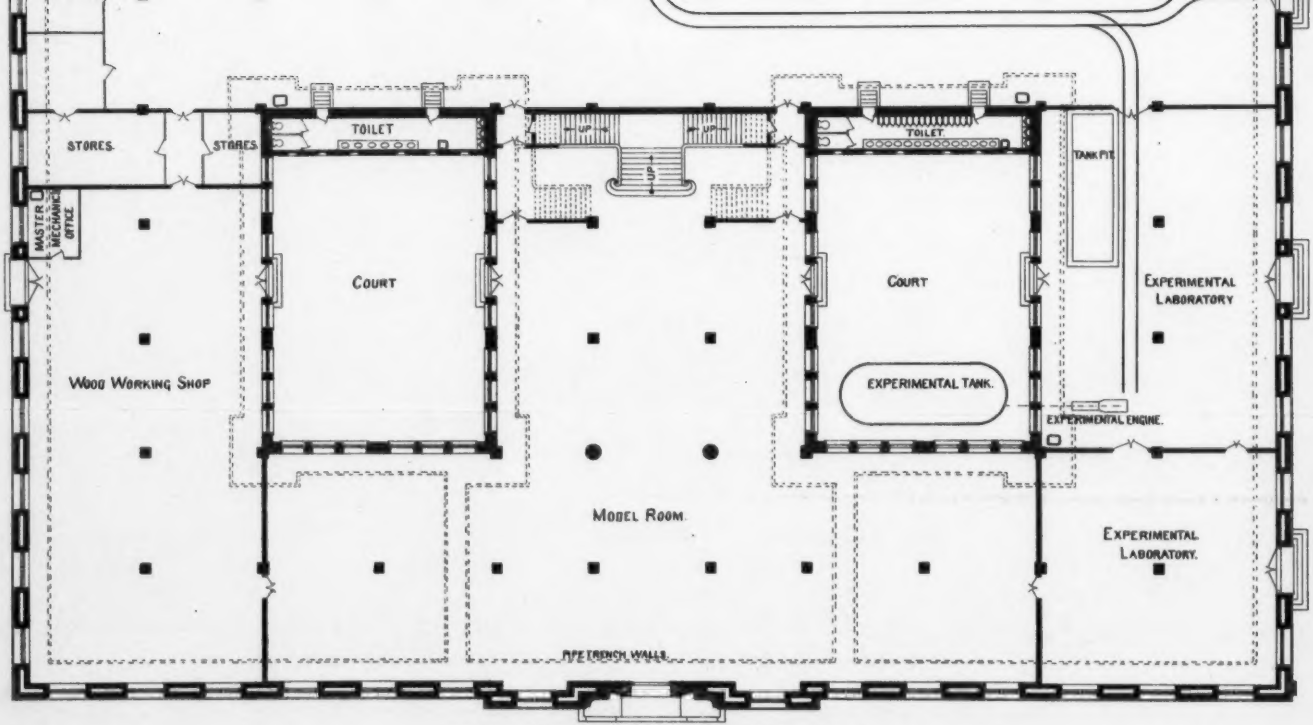
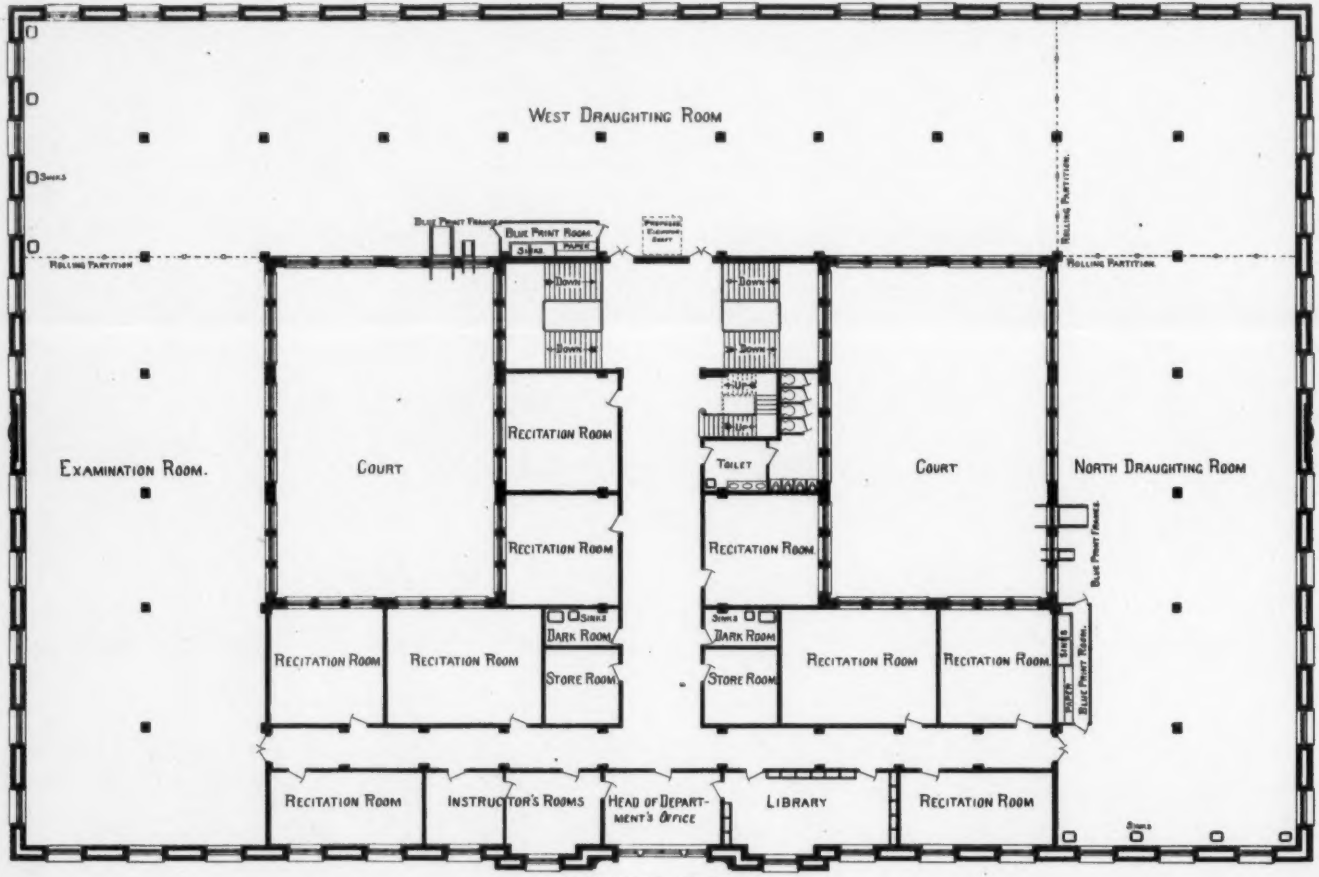




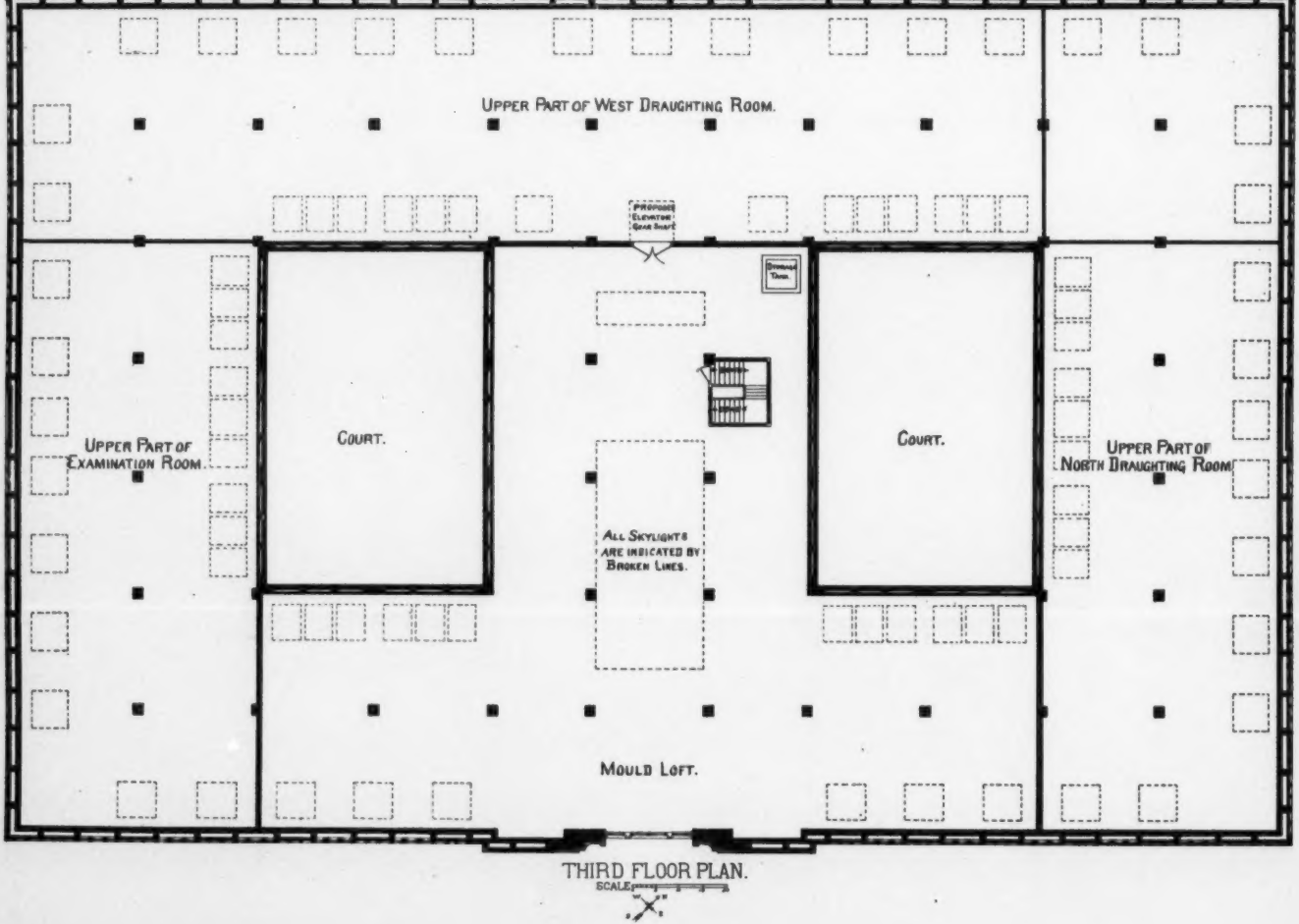
FIRST FLOOR PLAN OF MAIN BUILDING AND ANNEX.

SCALE



SECOND FLOOR PLAN

SCALE



THIRD FLOOR PLAN.

SCALE

capacity to accommodate all midshipmen in their studies of engineering and naval construction from their entrance into the Academy until their graduation.

In preparation for entrance into the new building a large addition has been made during the past year in the shape of electrically-driven tools, apparatus and machinery, especially in the model room, machine shop, laboratories and wood-working shop; while for the succeeding years the proposed plan is for a gradual installation of new material yearly from an appropriation deemed suited to the needs, until the building is thoroughly equipped.

For the model room numerous additions have been made in the various appliances in use for marine engines and auxiliaries, and, through the generosity of various engineering companies, material, and sectional and working models have been kindly donated. In addition, all the standard pumps in use in the Navy have been installed.

In the wood-working shop new lathes and other tools have been installed, bringing the shop to the present working capacity of fifty midshipmen.

In the drawing room the outfit has been enlarged by models on a reduced scale of various parts of actual engines used in the United States Navy, but with the number of midshipmen under instruction at the same time, the equipment in this respect is still far below the needs. With the progressive plan of installation, however, the defect in material of instruction in this, as in other branches of the engineering department, it is hoped will be remedied at an early date.

In the following description, together with the accompanying plates, the general arrangement, the features of the building and its capacity may be seen.

The main building is located in a northwesterly direction, on the axis of the proposed academic building and adjacent to the power-house pier. It is 266⅔ feet long, 175 feet wide, and is two stories in height, except the central part, between the interior courts and southeast fronts, which is three stories, the third story containing the mold loft. The roof is cov-

ered with slate and has hinged skylights on the exterior and court sides; there is also a large ridge skylight over the mold loft.

In the course of construction and not yet completed is a wing or annex on the northwest side, 116 feet long, extending 66 feet to the rear, and in communication with the machine shop. In this wing will be located the boiler room, foundry, forge shop and copper shop, with the proper equipment of a modern plant.

Main Building.—The total floor space in the main building is approximately 91,450 square feet, distributed as follows:

First floor, square feet, ...	39,100
Second floor, square feet, ...	39,100
Third floor, square feet, ...	13,250
Total, square feet, ...	91,450

The principal entrance is on the southeast side and faces an extension of College Avenue of the City of Annapolis. Additional main doorways for freight and material are located in the remaining sides of the building and communicate directly with the the shops; the main entrance leads through the model room to a large divided staircase leading to the upper floors.

The construction of the building is of ferro-concrete and thoroughly fireproof throughout; the exterior walls are of light gray brick with granite trimmings. Two light wells, 75 by 50 feet, open at the top and terminating in courts on the first floor, contribute to make the building well lighted throughout its interior.

First Floor.—The main entrance leads directly into the spacious model room, the shape of the latter being that of an inverted "T" and taking in two sides of each light well previously noted. This room contains types of the different auxiliaries, air, circulating, feed pumps, etc., found on board naval vessels, sectional models, valves and valve gearing, models of triple and quadruple-expansion engines, indicators,

types of steam-turbine vanes, model of steam-steering and capstan engine, full-size working model of the U. S. S. *Connecticut's* reversing engines, reversible ash-hoist engines, sectional and working models of steam-launch engines, working models of valve gear and link motion, elements of Niclausse, Babcock & Wilcox and Cahall boilers, together with the various naval construction models in the way of sections of various types of ships, working models of machinery under the cognizance of the Bureau of Construction and Repair. Various instruments of precision, fuel and gas-testing apparatus are contained in the cases surrounding the sides of the room.

Adjacent to the model room on the northeast side is the mechanical laboratory, divided into two parts; total area 125 feet by 50 feet.

The present equipment of the laboratory consists of:

1 Rand air compressor 10 inches by 14 inches, duplex steam, 16 inches by 10 inches by 14 inches compound air.
2 Wheeler condensers.
1 Triple-expansion experimental engine, with tank.
1 Dense-air ice machine, 1 ton.
1 Ammonia ice machine, 2 tons.
1 Evaporating plant, with pumps and distiller.
1 16-kw. marine direct-connected generator.
1 25-kw. Curtis steam turbine, with generator.
1 15-H.P. De Laval steam turbine.
1 Riehle testing machine.
1 Complete set of pneumatic tools, with all attachments.
2 Engines for disconnecting, making adjustments, etc.
1 Root blower.

Prony brakes, dynamometers, and engine and boiler-testing appliances.

Adjacent to the opposite side of the model room is the woodworking shop, 108 feet by 50 feet. The present equipment of this shop consists of 18 woodworking lathes, 1 power-driven band saw, 1 power saw bench, several hand-power tools, and benches and equipment for 32 midshipmen at bench work, making a capacity at present for 50 midshipmen, or, with

the installation of additional tools, a capacity of 75. The machinery is driven by a Crocker-Wheeler motor.

Behind the model room, woodworking shop and laboratory, and extending the entire length of the building, is the machine shop, 266⅔ feet long by 50 feet wide, fitted with store rooms, lavatories and tool rooms.

Equipment.—All machine tools, lathes, etc., in the old Steam Building found to be in good condition were transferred to the new building, arranged in two groups, belted up and driven by two separate group motors. All new installations were made with individual motor drives, and as far as possible of the different standard makers of both machines and motors, in order to give the midshipmen the opportunity of observing the different mechanical movements and to assist in the classroom instruction.

The equipment consists of :

37 Lathes from 14-inch swing up to 27-inch swing.
4 Planing machines.
6 Shaping machines.
4 Drill presses.
3 Sensitive drilling machines.
3 Milling machines.
1 Combined drilling and slotting machine.
3 Slotting machines.
1 Radial drill.
1 Spliner.
1 Grinding machine.
2 Boring machines.
1 Pipe-cutting machine.
3 Tool grinders.
1 Milling cutter and tool grinder.
1 Drill grinder.

Of these 15 lathes, 2 shaping machines, 1 drill press, 3 sensitive drills, 2 milling machines, 2 slotting machines, 1 radial drill, 1 planing machine, 1 combined slotting and drilling machine, 2 tool grinders and 1 drill grinder are motor driven.

To meet the large number of midshipmen in the lower classes as they reach the first and second classes an increase in machine tools and lathes will be required in the coming year, as with the present number all machines are constantly occupied.

At the end of the shop a space is reserved for a small erecting floor when its services will be required, while at the opposite end are placed tool rooms, extending the width of the shop, and separated from it by expanded metal screens.

A vise bench lines one length and width of the shop, and is fitted with 72 vises for the use of midshipmen engaged in bench work, the present complement now being 70 midshipmen, at this work.

The total complement at present engaged in the afternoon exercises in the machine shop, wood-working shop and laboratories is 193. In the coppershop, foundry, forge and boiler-shop in the old Steam Building there are at the same time 57 midshipmen, together with 30 engaged afloat in handling the machinery of the monitors *Nevada* and *Arkansas*, or the two torpedo-boat destroyers *Lawrence* and *Truxtun*, making a total of 280 midshipmen engaged in practical engineering instruction each day.

Surrounding the first floor is a large pipe trench containing all the steam, water and air piping connected to the various machines where required. From the air receiver of the air compressing machine a discharge pipe leads completely around the machine shop, laboratories and model room, with taps placed at convenient intervals, by means of which hose connections can be made to pneumatic tools in any of these shops, or connections made quickly and readily to models and machines desired to be operated for instruction purposes.

Second Floor.—In the center of the southeast side is the office of the head of department, and on either side, connected by communicating doors, are the instructors' rooms and a reference library and reading room. On this floor are nine commodious and well-lighted section or class rooms, two store rooms, two photographic dark rooms, and a toilet and coat room.

The drawing room is also situated on this floor, and consists of the entire rear and northeast wing, giving a floor area of 19,583 square feet, and, with drawing tables spaced 7 feet apart from center to center, accommodates a class of 325, leaving ample room for model tables, drawing-board cases, sinks, blue-print rooms and passage ways. This room can be still farther increased by throwing into communication with it, by means of rolling wood partitions, the southwest wing, now used as an examination room, 125 feet by 50 feet, and giving accommodation for 105 more drawing tables or for a class spaced for examination alone of 300 midshipmen. The actual number of midshipmen at present in these two rooms for examination in mathematics and engaged in mechanical drawing is 575.

The drawing room is well lighted by means of overhead skylights, outboard windows and windows opening into the light wells. For late afternoon work or winter-weather conditions portable electric lights lead from sockets under each drawing table. In addition to the ordinary blue-printing outfit of tracks and frames for sunlight printing a large electric blue-printing machine is installed, by means of which each midshipman can do his printing irrespective of weather conditions, and with a great saving of time, which is rather an important consideration in the course of mechanical drawing. Midshipmen are given free access to the drawing room, whenever their other duties permit, for any increased work in mechanical drawing they may desire.

Third Floor.—This floor has been designed as a mold loft, for the laying off of ships, the preparation of molds, templets and the usual work done in a mold loft. It is also fitted with draughtsman's tables for the use of upper classes in designing work and in illustrating the practical problems given out in the section rooms.

Electrical Work.—The building is very thoroughly equipped electrically. The lights are ample and sufficient, with convenient panels and switches, and include a complete bell and telephone system, together with the wiring necessary

for power purposes. Enameled iron-pipe conduits are used throughout for all wires of the light, power and call-bell services. The wiring is on the three-wire system throughout, except branch lamp circuits, which are of two wires.

The power circuit is divided into six circuits, consisting of one set of mains each for the following: The machine shop for the machinery motors, the woodworking shop, the model room, one to each experimental laboratory, and one for future use in a freight lift in the machine shop. These mains are large enough to supply current for all the machinery motors in use at present and for the future installation.

From the office of the head of the department interior telephones lead to all the shops, class rooms, and instructors' rooms.

Shop Building.—The shop building or annex to the Engineering and Naval Construction building is located in the rear of the main building on the axis of the same.

The building is one story in height, with a covered terrace connecting it with the main building, and the general floor is directly on the ground surface.

The structural parts of the building, including interior and exterior columns, foundation piles, wall supports, cupola, charging platform, and the entire building with the exception of the lantern, is of ferro-concrete construction and fire proof throughout.

When completed the building is to contain the foundry, forge and boiler shops, cupola, platform and lift to the same, brass furnaces, pipe trenches, etc. The floors are to be of concrete and cement, excepting that portion of the foundry requiring a dirt floor.

Forge.—Referring to the plans of the annex, the forge shop has an area of 50 feet by 65 feet with a down-draft forge equipment of twenty-eight forges, with the necessary outfit of exhausters, blowers, anvils, forge tools, vise benches, etc., a steam hammer with attachments, and an oil-annealing and hardening furnace.

The total capacity of this shop for instruction will be about forty midshipmen.

Foundry.—The foundry is 66 feet by 32 feet, and the present designed equipment is for a small cupola complete with blower, elevator to charging door, core oven, cranes, crane ladles, and a complete outfit of molding implements.

In the shop will also be installed brass furnaces for use in brass casting, and consisting of one or two Rockwell rotary melting furnaces complete. Oil fuel will be used in this connection with oil burners, compressor or pressure blower, storage tank, the necessary piping, oil pump and ladle heater.

One section of this shop will be devoted to elementary instruction in coppersmithing in the ordinary work usually found on board of a naval vessel. Capacity, about forty midshipmen.

In the rear of the foundry is the boiler shop, 66 feet by 32 feet, to be equipped with a Ward round boiler, and two proposed small units of the typical water-tube boilers found on board battleships and armored cruisers of our Navy. As the drive of all the machine tools in the department is electrical, these boilers will be of small capacity, about 75 or 100 H.P. each (commercial), to be used for boiler-test instruction, and for driving the various auxiliaries, ice machines, air compressors, experimental engines, etc., in the laboratories.

In addition to the above installation the shop will be fitted as a boiler-repair shop for the instruction of midshipmen, in which the various operations of shell boiler construction and repair may be illustrated, together with the work of construction and repair of water-tube boilers. Space and material can be provided for the instruction of about forty midshipmen.

Cost of the Structure.—The cost of the engineering building and annex, including foundation and preparations for the same, but without furniture and equipment, is as follows:

For the main building, . .	$360,000.00
annex, . . .	40,000.00
Total, ...	$400,000.00

With the completion of the annex, its installation of tools and the continuance of the work of fitting up the shops, laboratories and model rooms of the main building, all of which will probably be well finished during the coming year, and with the present system of summer practice cruises where the midshipmen cruise in a squadron composed of types of ships from a destroyer to a battleship, with engineering duty on each type, the facilities offered for practical engineering training have never been equaled by any class previous to the enactment of the Personnel Law, whether of the engineers or of the line.

With this elementary training at the Naval Academy, the suggestion outlined in the annual report of the Chief of Bureau of Steam Engineering, 1904, as to the necessity of giving a sufficient quantity of engineering duty on board ships to all line officers, at first in a subordinate capacity, to render them qualified to take charge of the engineering departments of any and all ships, and to select annually from among the list of ensigns a certain number of officers for the performance of engineering duty alone, would seem to offer a practical solution to the problem of obtaining an efficient engineering personnel for duty on our battleships and cruisers, furnish the professional training for the inspection of structural work and for the management of the engineering department in our navy yards and shore stations.

CONTRACT TRIALS OF SHIPS AS EXPERIMENTS UPON PROPELLERS.

By John Lowe, Rear Admiral, U. S. N., Retired.

Anyone interested in the sea and in ships can find in the Journal of the American Society of Naval Engineers much information of great value; but of all the information therein contained, that which is of most value to the naval architect and engineer is that which relates to the contract trials of naval vessels. Especially to that class engaged in the study of the screw propeller the information there furnished is of indispensable value, and to this class this paper is addressed, with the purpose of showing that this data can furnish complete experiments upon the screw propeller, unsurpassed even by tank experiments.

The method is a trial-and-error process, somewhat akin to the Sumner method in navigation, whereby the efficiency of the screw, its friction, the thrust, and so forth, can all be ascertained, beside simultaneously testing the method and means employed.

Let (IHP) represent the power applied to one screw to propel the ship. Of this power a portion is absorbed in engine friction, the amount of which, in the light of many experiments, lies in the neighborhood of 28 per cent., leaving 0.72 (IHP) as the net power to revolve the screw.

This net power by the elder Froude was termed the "turning moment," and we will accept this value 0.72 (IHP) for this moment and represent it by (Z).

Now (Z) is to be again subdivided into three components:

(F) is the power consumed in friction and other resistance to the passage of the screw through the water.

(S) is the power lost in slip.

(A) is the remainder, usefully applied to propulsion.

(δ) is the slip unit given in every trial.

Since $e = \frac{A}{Z}$ is the efficiency of the screw, we have $A = eZ$; $S = \delta Z$ and $F = (1 - (e + \delta))\ Z$, or, for brevity, $F = cZ$.

The problem is to find e, and therefore each of the subdivisions. The process will also test the method as well as the means employed.

The method requires us to systematically pair two ships against each other and compare the data obtained from their contract trials.

We select two pairs: the armored cruiser *Colorado*, of 14,500 tons, against the torpedo boat *Rodgers*, of 147 tons, as one pair, while the battleship *Ohio* will be paired with the torpedo boat the *Winslow;* the dissimilarity could hardly be greater.

For our convenience, we extract from the trials the data that we need, and tabulate as follows.

Symbol employed.	Z	R	δ	P	r	Φ
				Propeller.		
Vessel.	Turning moment.	Revolutions per minute.	Slip unit.	Pitch, feet.	Radius, feet.	Projected area, square feet.
Colorado	9,410	126.79	0.192	22	9	74
Rodgers	830.16	395.8	0.2094	7.82	2.625	7.93
Ohio	5,740	123.85	0.156	17.25	8.125	75
Winslow	830.16	393.92	0.1816	7.80	2.625	7.93
Kentucky	4,350	114	0.1293	17.25	8.375	69.2

The trial and error method now follows. First, we assume a larger value for (e) than it can possibly be, and tabulate it in column e of the following tables. In column δ we tabulate the unit slip obtained from the data, and in column (c) we tabulate $c = (1 - (\delta + e))$ for use with $F = cZ$, as previously explained. Next, we assume smaller and smaller values of

For the *Colorado*.					For the *Rodgers*.				
Efficiency assumed value. e	Obtained from the trial. δ	$\epsilon = 1 - (\delta + e)$. ϵ	Logarithm. f	Logarithm. C	Efficiency assumed value. e	Obtained from the trial. δ	$\epsilon = 1 - (\delta + e)$. ϵ	Logarithm. f	Logarithm. C
0.73	0.1920	0.078	—11.8023	13.0644	0.66	0.2094	0.1306	—11.7887	12.2463
0.721	0.1920	0.087	—11.8487		0.64	0.2094	0.1506	—11.8506	
0.72	0.1920	0.088	—11.8537		0.6392	0.2094	0.1514	—11.8531	
0.70	0.1920	0.108	—11.9426		0.63915	0.2094	0.15145	—11.8536	
0.69	...	...	...		0.6391	0.2094	0.1515	—11.8541	

For the *Ohio*.					For the *Winslow*.				
e	δ	ϵ	f	C	e	δ	ϵ	f	C
0.708	0.156	0.136	—11.8529	13.0394	0.69	0.1816	0.1284	—11.8257	12.2027
0.709	...	0.1361	—11.8532		0.683	0.1816	0.1354	—11.8487	
0.7078	...	0.1362	—11.8535		0.682	0.1816	0.1364	—11.8529	
0.7077	...	0.1363	—11.8538		0.6815	0.1816	0.1369	—11.8539	
0.707	...	0.137	—11.8561		0.68	0.1816	0.1384	—11.8583	

(e) until a smaller value is reached than can be expected, and fill the table as just explained.

Now, then, we employ the friction formula of the appendix, but right here we remark that this formula has not yet been accepted—it is yet upon trial along with the method; we accept it, however, provisionally.

Into this formula we insert the data obtained from the trial, and so obtain the value of (fC), as explained.

We then have the equation $cZ = fC$ to find (f), which we tabulate appropriately, and the tables are ready, and the problem is solved as follows.

We have assumed for (e) values which are too great, and have filled the tables with values smaller and smaller until the value is too small.

(1) Somewhere between these extremes lies the true value.

(2) There is only one true value for (f), all the others are in error.

(3) The correct value lies in both tables, that value which is the same in each is manifestly the correct value. In other words, each table being plotted as a line, each line intersects at the point where the value of $\log(f) = -11.8536$, giving for the *Colorado*, $e = 0.72$; for the *Rodgers*, $e = 0.639$.

Now, since these values accord with experience, and because of the coincidence of (f), we are justified in saying that the truth of the method of the friction formula and of the results are probably proven. When, however, we find the same coincidence in a second pair, as in the table for the *Ohio* and the *Winslow*, giving the precisely same value for (f), then we are justified in saying that probability ceases and certainty commences; and when many other pairs of which these two are only samples, give like results, then we are completely justified in asserting the methods, the means and the results, as demonstrated.

We have, therefore

$$e = 1 - \left(\delta + \frac{F}{Z}\right)$$

in which

$$F = f\psi R^3 \left(\frac{P^4}{\pi\gamma} + \frac{8}{3} P^2 \pi r + \frac{16}{5} \pi^3 r^3 \right) : \log (f) = -11.8536$$

δ and Z taken from any trial under investigation.

Therefore, any single trial without reference to others may give a complete analysis of the performance of a screw propeller.

Example, the *Kentucky*, $e = 1 - \left(0.1293 + \frac{615}{4350}\right)$, $e = 0.7292$.

APPENDIX.

FRICTION OF A SCREW PROPELLER.

Imagine a metallic plane with the surface of (S) square feet, the thickness very small, immersed in water, and forced to move therein in the direction of its length.

It will experience a resistance measured in pounds equal to the effort required to maintain motion.

It is generally conceded that the law and the amount of this friction is expressed in the equation $F = fv^2S$, and the work done in overcoming this resistance is $Fv = fv^3S$ foot pounds per second.

The screw propeller consists of a large number of such planes, and the friction of the entire propeller is the sum of the friction of all these elementary planes.

Consider the work done upon one of these planes, situated in radius (r) feet from the center, in a propeller of (P) feet pitch revolving at the rate of $\left(\frac{R}{60}\right)$ revolutions per second, the length of the plane being (l) feet and its thickness dr feet.

The path of this plane will be in a helix, its velocity $v = \frac{R}{60}\left(P^2 + (2\pi r)^2\right)^{\frac{1}{2}}$ feet per second, and its surface $S = 2ldr$.

The work done per second upon this plane will be

$$dW = f\frac{R^3}{60^3}\left(P^2 + (2\pi r)^2\right)^{\frac{3}{2}} 2ldr, \quad . \quad . \quad . \quad . \quad (1)$$

This is a complete algebraic statement of the method employed by Isherwood for measuring the friction of one element.

A large number of such elements being measured and figured were set up as ordinates, and the sum or integral of them all was obtained by any of many well known methods.

This method, though unsurpassed for accuracy, is exceedingly laborious in practice, even to a prohibitive degree.

This summation or integration may be more rapidly and more accurately obtained by means of the Integral Calculus.

Let (l) be some fraction (k) of the helix; then

$$l = k(P^2 + (2\pi r)^2)^{\frac{1}{2}},$$

which being substituted in equation (1) becomes

$$dW = 2f \frac{R^3}{60^3} k\left(P^2 + (2\pi r)^2\right)^{\frac{1}{2}} dr,$$

which being expanded becomes

$$dW = 2f \frac{R^3}{60^3} k(P^4 dr + (8P^2\pi^2 r^2 dr) + 16\pi^4 r^4 dr.$$

Integrated,

$$W = 2f \frac{R^3}{60^3} k\left(P^4 r + \frac{8}{3} P^2\pi^2 r^3 + \frac{16}{5}\pi^4 r^5 + o\right)$$

foot pounds per second.

Now, in this equation, k occurs as a coefficient in single ratio, and since its value varies along the blade, it is necessary to obtain its mean value, which is easily proven to be $k = \frac{\Phi}{\pi r^2}$ where φ is the projected area of the screw.

Substituting and reducing to horsepower units, we get

$$F = \frac{2f\Phi R^3}{60^2 \times 33000}\left[\frac{P^4}{\pi r} + \frac{8}{3} P^2\pi r + \frac{16}{5}\pi^3 r^3\right]$$

in horsepower units.

We may, however, collect all the constants into one, and write

$$F = f \Phi R^3 \left(\frac{P^4}{\pi r} + \frac{8}{3} P^2 \pi r + \frac{16}{5} \pi^3 r^3 \right),$$

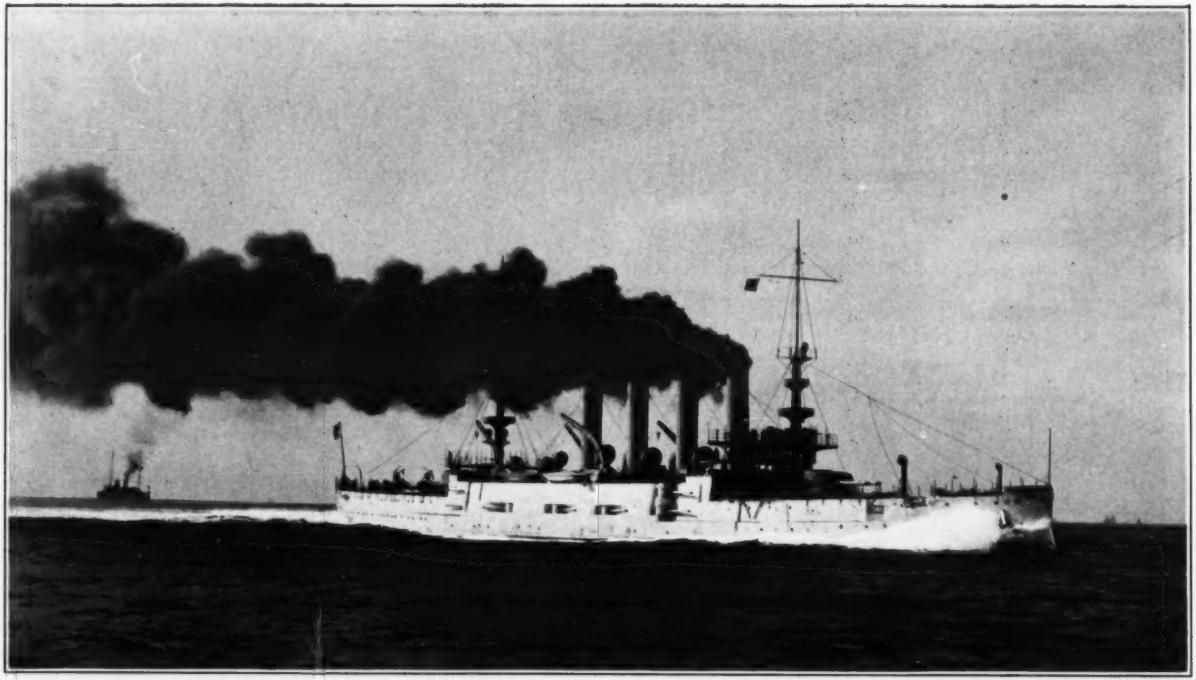
and we can get the value of f as in the main paper,

$$\log f = -11.8536.$$

If, whenever speaking of the formula we desire brevity, it may be done by representing the bracket by B, and we write

$$F = f \Phi R^3 (B).$$

If we desire to discuss and compare two propellers or more as to friction, then we obtain all these values, and write $F = fC$, which is the form used in the main paper.



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U. S. Armored Cruiser "West Virginia."

UNITED STATES ARMORED CRUISERS *WEST VIRGINIA* AND *MARYLAND.*

DESCRIPTION OF VESSELS.—OFFICIAL TRIAL PERFORMANCE.

By Lieutenant Commander W. Strother Smith, U. S. N., Member.

In accordance with an act of Congress appropriating for the increase of the Navy, the contract was signed on January 24, 1901, by the Newport News Shipbuilding and Drydock Company, for the construction of the hull and the machinery of the U. S. armored cruisers *West Virginia* and *Maryland.* As originally designed, the *West Virginia* was to be sheathed and her sister ship unsheathed, and the contract prices were $3,885,000 and $3,775,000 respectively. Subsequent to the signing of the contract it was decided between the contracting parties not to sheath the *West Virginia*, and there was made a decrease in the contract price of $135,931 for this vessel. The armor and armor bolts (exclusive of protected deck), ordnance and ordnance outfit and certain articles of equipage are supplied by the Government and their cost is not included in the contract price, but the expense of fitting and installing these is borne by the builders.

The date of completion by contract was fixed at January 24, 1904, but the time has been extended for just cause until February 6, 1905.

The speed called for was to be 22 knots per hour with a mean draught of 24 feet 6 inches and with an air pressure of 1 inch in the ash pits. Previous to the trial, the draft was changed to 24 feet 1 inch, and 2 inches of air pressure was allowed. It was stipulated that the vessels should be accepted if the speed did not fall below 20 knots at a decreased cost of $50,000 per quarter knot between 22 and 21 knots, and $100,000 per quarter knot between 21 and 20 knots per hour. Below 20 knots it was optional with the Secretary of the Navy to reject the vessel so failing or accept her at a cost to

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be agreed upon between the contracting parties. No bonus was to be allowed for any increase over the 22 knots.

The full complement of officers and men will be 808.

HULL DATA.

HULL.

Length between perpendiculars, feet	502
on L.W.L., feet	502
over all, feet and inches	503–10½
Beam, extreme, feet and inches	69– 6½
at L.W.L., feet and inches	69– 6½
Ratio of length to beam	7.24
Depth (molded), feet and inches, main deck	41– 2
upper deck	48– 8¾
Height, flying bridge above main deck, feet and inches	24– 0
Draught, normal, mean, feet and inches	24– 1
Displacement, full load draught (empty bunkers), tons	13,226.4
normal draught (24 feet 1 inch), tons	13,720
full load draught (full bunkers), tons	15,170
per inch at L.W.L., tons	58.15
Area midship section to L.W.L., square feet	1,598
L.W.L., plane ( ), square feet	24,380
Wetted surface, square feet	42,850
Center of gravity of L.W.L. plane, aft of M.S., feet	7.85
buoyancy above bottom of keel, feet and inches	13–4¼
aft of M.S., feet	3.13
gravity above bottom of keel, feet	——
Transverse metacenter above center of buoyancy, feet	14.94
Longitudinal metacenter above center of buoyancy, feet	652.5
Coefficient of fineness block	.569
of M.S.	.954
L.W.L.	.696
Cylindrical coefficient	.596
Number of frames	124
watertight compartments	269

The keel of the *West Virginia* was laid on September 16, 1901, and that of the *Maryland* on October the 29th, of the same year, and, with the exception of the change of one stateroom on the *Maryland* to an office for the chief of staff, the only difference between the two ships is the name on the stern. The hull is built of basic, open-hearth steel, with the frames spaced 4 feet apart, except under the machinery and boilers. The inner bottom extends from frame 20 to frame 102, compartments B 78, 79, 82, 83, 86, 87, 90 and 91 and are arranged

for reserve-feed water tanks, and are situated between frames 40 and 53, and are those on each side of the vertical keel.

A cofferdam extends the whole length of the ship on the protective deck; between frames 40 and 92 it is carried above the berth-deck level, and is filled with cornpith cellulose both forward and aft of these frames only.

Practically all of the wood work that is not fairly portable and can be dispensed with in time of war or thrown overboard before going into action is fire-proofed, except the teak armor backing, the wood work of the chart and pilot house, and the wood work below the protective deck.

The bridge deck and main decks are laid with wood, the others being covered with linoleum.

There are two military masts, each with three tops for machine guns on the lower two and searchlights on the upper.

THE BRIDGE DECK.

The bridge deck extends between the two turrets and forms the upper part of the superstructure. Over the forward end of the bridge deck is built the pilot house, chart room and emergency cabin, and above this is the flying bridge. Over the after end is the signal bridge, at the level of the top of the signal tower.

The following boats are carried on the bridge deck:

1 50-foot picket boat.
1 36-foot steam cutter.
1 33-foot steam cutter.
2 36-foot launches.
5 30-foot cutters.
1 30-foot barge.
2 30-foot whale boats.
1 30-foot whale-boat gig.
2 20-foot dinghys.
1 16-foot dinghy.
1 14-foot dinghy.
1 12-foot punt.
2 Carley life rafts.

These boats are handled by one 15-ton, one 10-ton and two 3-ton electric cranes.

THE MAIN DECK.

This deck extends from stem to stern, and is partially covered by the bridge deck between the two turrets. The hawse pipes extend through the bow to this deck, and protecting plates are worked in to carry the chains to the windlass house, which is partly on this deck.

The two 8-inch gun turrets, the four 6-inch guns in separate casemates, and eight 3-inch R. F. guns are mounted on this deck. The 6-inch and 3-inch guns are covered by the bridge deck.

In the forward part of the superstructure is the bakery, the crew's galley, the Admiral's and Captain's galley, and the officers' galley. Abaft of the fireroom hatch are four rooms: the two forward are the printing office and wireless-telegraphy room; the two after ones are staterooms for two warrant officers. Between the two after 6-inch gun casemates are the warrant officers' mess room and pantry, and abaft the 'thwartship armor are situated the executive officer's stateroom, bath and office, the paymaster's office, the navigator's office and the ordnance officer's office.

THE GUN DECK.

From forward to aft on this deck comes the crew's shower bath, lavatory and head, windlass house; the casemate, containing the ten 6-inch guns, six warrant officers' staterooms, the staterooms of the senior engineer officer, navigator, paymaster, surgeon and flag lieutenant; the captain's cabin, stateroom, bath and office; the chief of staff's cabin and bath, and the quarters for the Admiral. Within the casemates are ten 6-inch B.L. rifles, separated by splinter bulkheads, the armory, the engineer's office, the mine room, and the general mess pantry.

On the *Maryland* the office of the chief of staff takes the place of the flag lieutenant's stateroom on the *West Virginia.*

THE BERTH DECK.

The after berth deck, from the 'thwartship armor, contains the junior officers and ward-room pantries, the mess room and

twelve staterooms for junior officers; the ward-room mess room, extending the width of the vessel, with two circular and two large square air ports on each side; sixteen staterooms for ward-room officers, in two compartments, and the ward-room lavatory.

The forward berth deck contains the paints and oils, the brig, the contagious ward, the chief petty officer's quarters, staterooms for the master-at-arms and the sergeant of marines, refrigerating rooms, ice machine, laundry, drying room and sick bay, with operating room, dispensary and bath.

The sick bay is the most commodious and the best equipped of any heretofore installed in any vessel of the United States Navy, situated about one-fourth of the ship's length from the bow, having a clear space of 8 feet 9 inches under the beams, being well lighted and ventilated and having ample room in bunks for about five per cent. of the ship's crew. The contagious ward has four additional bunks. The operating room is adjacent to the sick bay and is well lighted and commodious, the deck is tiled and is easily cleaned.

THE ARMOR.

The armor consists of the side belt of Kruppized nickel-steel, 6 inches thick abreast of the machinery space and 3½ inches thick forward and aft of this. Above the belt armor is the lower casemate armor of 5 inches, the upper casemate of 5 inches and the superstructure armor of two inches, except around the 6-inch guns, where it is 5 inches.

The conning tower is 9 inches and the signal tower is 5 inches thick.

There are two elliptical balanced turrets, revolving over circular barbettes. The turret armor is 6½ inches on the inclined face, in which the gun ports are cut, and 6 inches on the vertical; the barbette armor is 6 inches. All 3-inch R.F. guns are protected by 2 inches of armor.

The casemate protection at the forward and after ends is 4 inches from the bridge deck to the protective deck.

The protective deck consists of two 30-pound plates, and this is further protected by one 100-pound plate on the slopes.

ORDNANCE.

Main battery:

Four 8-inch 40-caliber breech-loading rifles.
Fourteen 6-inch 50-caliber breech-loading rifles.

Secondary battery:

Eighteen 3-inch 50-caliber rapid-fire rifles.
Twelve 3-pounder rapid-fire rifles.
Four 1-pounder automatic.
Four 1-pounder Hotchkiss rapid-fire rifles.
Six 30-caliber Colt's automatic.
Two Gatling guns.

THE MAIN ENGINES.

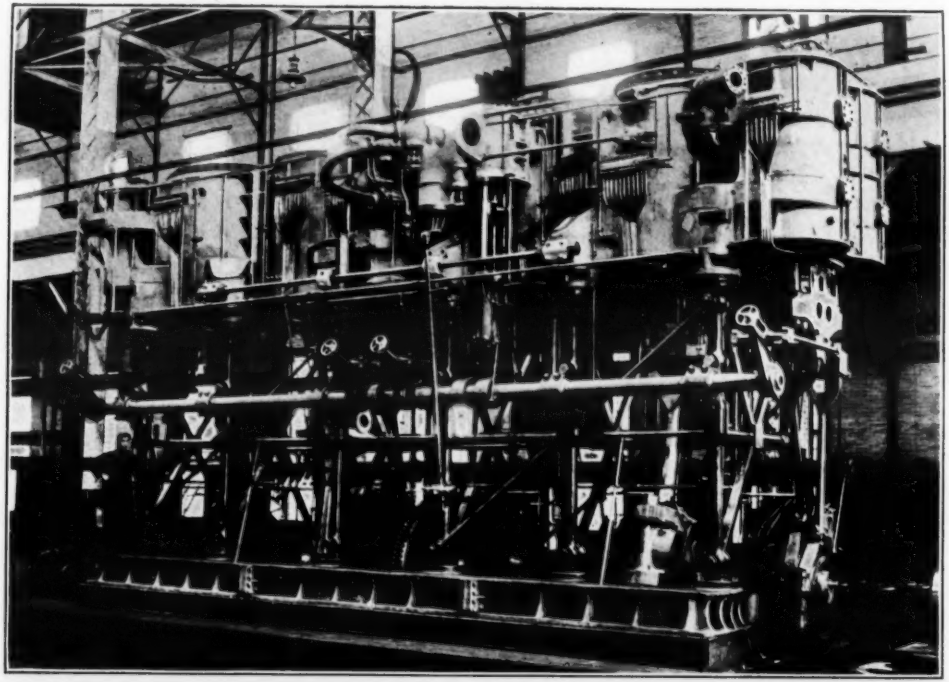
There are two four-cylinder triple-expansion engines of the vertical, inverted, direct-acting type, in separate watertight compartments. The order of the cylinders is: the forward L.P., the H.P., I.P and after L.P. The H.P. and I.P. cranks are at ninety degrees, and the two L.P. cranks at the same angles. The H.P. and F.L.P. cranks are opposite.

The cylinders are supported by twelve forged, nickel-steel, cylindrical columns which are tied fore and aft by heavy cast-steel I braces and diagonal rods and strengthed 'thwartships by X frames bolted to the columns at top and bottom and stayed by through tie bolts and distance pieces at center of X.

All valves of the single-ported piston type, of cast-iron heads, with cast-iron packing ring and steel follower. The I.P. and L.P. valves take steam from the outside and the H.P. valves from the inside. The valves are arranged to lift through the upper head. The H.P. cylinder has one valve, and there are two for each I.P. and L.P. cylinder. Each valve is provided with a balance piston working in cylinder cast with the upper valve chest covers.

The valve gear is of the Stephenson type with double-bar links. The H.P. valve stem connects with its link block direct, while the I.P. and L.P. stems are connected by means of a crosshead.

The engines are operated by a floating-lever, steam reversing



ONE MAIN ENGINE, U. S. S. "WEST VIRGINIA."

cylinder whose piston rod carries a piston through an oil-control cylinder and is connected to the reverse shaft supported on the engine columns. This reverse shaft carries the reverse arms, in which independent adjustable cut-off blocks are fitted to connect to each link, giving a range of cut-off from .5 to about .73 of the stroke. When the H.P. crank is on the center live steam may be admitted into the I.P. and L.P. receivers.

All the cylinders are jacketed around the working liners and at both ends. The live steam at working pressure enters the high-pressure jackets, and from thence by reducing valves goes to the I.P. and L.P. jackets. Each engine has a 13-inch throttle valve, balanced by a piston working in the cylinder cast with the valve casing.

The H.P. pistons are of cast iron and the others are of cast steel, conical in shape; the followers are of cast-steel, the H.P. and I.P. packing rings are solid cast-iron rings kept central by springs, and the L.P. piston packing is two rings of segments set out by steel springs. The piston rods are hollow, of high-grade nickel-steel, oil tempered and annealed. They are accurately ground, cylindrical and polished, tapered at each end to fit the piston and crosshead. The crosshead is of nickel-steel, forged with the crosshead pins, and is bolted to the cast-steel slipper. The go-ahead guides are of cast-iron, hollow for water circulation, and are supported by being bolted to lugs on the cylinders at the top and to the cast-steel brace beam at the bottom. The backing guides are of cast steel and are bolted to flanges on the ahead guides.

The connecting rods are of the same material as the piston rods, are hollow, are forked at the upper end to carry the crosshead brasses. The crank-pin brasses are of composition and are held to the stub end of the connecting rod by a steel cap and through bolted.

The eccentrics are in two parts, the larger of cast iron and the smaller of wrought steel. The eccentric straps are of composition, the rods of high-grade nickel-steel.

The turning engine is a double, inverted engine, secured to

the engine bed plate and connected by worm gearing to the crank shaft.

The working platforms are inboard; the reversing lever, the throttle wheel, and engine telegraph are placed within easy reach of each other; the H.P. valve-chest steam gauge is at the throttle. The clock is on the center-line bulkhead over the engine-room desk, and directly beside it are the counters, worked by gears and shafting from the thrust shaft.

ENGINE DATA.

Cylinders, number for each engine	4
H.P., diameter, inches	38.5
I.P., diameter, inches	63.5
L.P., diameter, inches	74
Stroke of all pistons, inches	48
Valves, H.P. (one for each cylinder), diameter, inches	23
I.P. (two for each cylinder), diameter, inches	25.5
L.P. (two for each cylinder), diameter, inches	28.5
Valve stems, forged nickel-steel, diameter, inches, H.P. $3\frac{3}{8}$, I.P. $3\frac{1}{2}$, L.P.,	$3\frac{1}{2}$
diameter through valve, inches	$2\frac{1}{2}$
at balance pistons, inches	$1\frac{5}{8}$
Main steam pipe, diameter at throttle, inches	13
area of cross section, square inches	132.73
Volume swept by H.P. piston, mean, per stroke, cubic feet	31.55
I.P. piston, mean, per stroke, cubic feet	87.18
both L.P. pistons, mean, per stroke, cubic feet	237.36
Net area of I.P. to H.P. piston	2.76
both L.P. to H.P. pistons	2.72
Piston rods, diameter, inches	$8\frac{1}{2}$
of axial holes, inches, H.P. and I.P., $4\frac{1}{2}$; L.P.,	5
length, feet and inches	9-$9\frac{1}{2}$
Cylinder walls of H.P., I.P. and L.P. cylinders, thickness, inches	$2\frac{1}{4}$, $1\frac{7}{8}$, $1\frac{5}{8}$
liners of cylinders, thickness, inches, H.P. and I.P., $1\frac{3}{8}$; L.P.,	$1\frac{1}{2}$
Valve-chest liners, thickness, inches	$1\frac{3}{8}$
Jacket space, inch	$\frac{5}{8}$
Cylinder relief valves (two on each cylinder), diameter, inches	$4\frac{1}{2}$
Connecting rod, length, center to center, inches	96
diameter, upper end, inches	$8\frac{1}{2}$
lower end, inches	$9\frac{1}{2}$
axial hole, inches, H.P. and I.P., 5; L.P.,	$5\frac{1}{2}$
crosshead bolts (four), diameter, inches	$3\frac{1}{2}$
crank pin bolts (two), diameter, inches	$4\frac{1}{2}$
Crosshead, surface, ahead, square inches, H.P. and I.P., 717.1; L.P.,	525.3
backing, square inches, H.P. and I.P., 230.8; L.P.,	294.7
pin, diameter, inches	$10\frac{1}{2}$

Crosshead, diameter of axial hole, double tapered, inches	7 to 2
length of pin, inches	11
Crank shaft, number of sections	2
diameter, inches	18½
of axial holes, inches	10
coupling discs, inches	32
thickness coupling discs, inches	4½
coupling bolts in one flange (twelve), diameter, inches	3¼
journals, diameter, inches	18½
forward to aft length, inches, 4 of 22½, 1 of 35 and 1 of	29½
length of forward sections, feet and inches	16–8½
length of after sections, feet and inches	18–7½
maximum distance between journals, feet and inches	6–5 9/16
pin, diameter, inches	20
length, inches	23
projected area, square inches	460
diameter, axial holes, inches	12
webs, width, inches	22½
thickness, inches	11
Thrust shaft, diameter, inches	17¼
axial hole, inches	10½
collars, number on each shaft	12
diameter, inches	27
thickness, inches	2
space between, inches	4
total thrust surface both engines, sq. inches	7,802.6
length, feet	13
steady bearings, inches	26
Line shaft, diameter, inches	17½
axial hole, inches	10½
coupling discs, inches	32
coupling bolts in one flange (twelve), diameter, inches	3¼
length, feet and inches	23–3
Propeller shaft, without casing, diameter in strut bearing, inches	forward 18 7/16; aft, 18½
length, feet and inches	47–11¼
Stern-tube shaft, after stern-tube bearing, inches	18½
forward stern tube bearing, inches	18 9/16
length, feet and inches	39–8
Inboard collar coupling, diameter, inches	33½
length, inches	22
of collar, inches	14
Stern-bracket bearing, diameter, inches	forward, 20 1/16; aft, 20¼
length, inches	forward, 35¾; aft, 59½
Reversing engine, diameter of steam cylinder, inches	16
controlling cylinder, inches	8
stroke, inches	22
Turning engine, diameter of steam cylinders (two), inches	7
stroke of pistons, inches	5

	Star.	Port.	Star.	Port.
West Virginia:				
Clearance of H.P. cylinder, per ct., top,	25.22,	21.91;	bottom, 27.81,	29.01
I.P. cylinder, per ct., top,	20.06,	20.51;	bottom, 22.90,	22.52
F.L.P. cylinder, per ct., top,	16.62,	16.73;	bottom, 19.62,	19.19
A.L.P. cylinder, per ct., top,	16.17,	16.34;	bottom, 19.84,	19.05
Maryland:				
Clearance, H.P. cylinder, per cent., top,	24.18,	26.77;	bottom, 29.55,	27.38
I.P. cylinder, per cent., top,	20.82,	20.13;	bottom, 24.14,	23.37
F.L.P. cylinder, per ct., top,	15.72,	15.95;	bottom, 19.65,	19.28
A.L.P. cylinder, per ct., top,	16.39,	16.17;	bottom, 19.79,	19.62

MAIN CONDENSERS.

There is one main condenser in each engine room. The shell is of steel, the water heads of composition, the tubes are of Admiralty metal, not tinned. There is a by-pass in the division plate of the water chest at the injection and delivery end, to allow the circulating pump to deliver directly overboard when working on the bilge, injection or the main drain.

Diameter of shell (inside), feet and inches	7- 5
Thickness of shell, inch	$\frac{7}{16}$
Length over heads, feet and inches	16-10
Tubes, diameter (outside), inch	$\frac{5}{8}$
length between tube sheets, feet and inches	14- 0
thickness, No. 18, B.W.G., inch	.049
spacing between centers, inch	$1\frac{1}{16}$
number in each condenser	6,292
Condensers (two), cooling surface, square feet, each	14,411

MAIN AIR PUMPS.

There is located abaft the condenser in each engine room one Blake, two-cylinder, vertical, double-acting air pump. There are suction valves below the pump piston, and these are reached by removing large man-hole covers that form a part of the pump barrel. The valves in the pump piston may be reached in the same manner when the piston is at the bottom end of its stroke.

Diameter of cylinders, inches, each	14
pump cylinders (two), inches	35
Stroke, inches	18
Diameter of piston rods (nickel steel), inches	$2\frac{1}{2}$
pump rods (Tobin bronze), inches	$3\frac{1}{2}$
pump valves in bucket, inches	$5\frac{1}{2}$
Number of delivery valves in each end	18
Area through 18 valve openings, square inches	234
by lift, square inches	185.55

MAIN CIRCULATING PUMPS.

There is one centrifugal, double-inlet, circulating pump driven by a two-cylinder, compound, vertical, inverted engine located forward of the main condenser. Each pump has a capacity of 15,000 gallons of water when its engines are run at 266 revolutions per minute. Each pump draws from the sea, the main drain and from the engine-room bilge, and discharges through the condenser or directly overboard, through the condenser by-pass, to the overboard delivery. The suction valves to these pumps are so locked that the sea valve and the bilge or drain valve cannot be open at the same moment.

Diameter of steam cylinders (two), inches	H.P. 11, L.P. 22
Stroke, inches	10
Diameter of pump runner, inches	45
Width of pump runner at periphery, inches	4
hub, inches	$10\frac{9}{16}$
Diameter of inlet and outlet nozzles, inches	two $15\frac{1}{4}$ and one 21

FEED AND FILTER TANKS.

There is in each engine room, under and extending to the air pump, a feed tank. Over the after end of the feed tank, and combined with it, is a filter tank of 6,500 gallons capacity for both tanks. The discharge from the main air pump, from the auxiliary condensers and from the dynamo condenser, on the port side, enters the first compartment of the filter tank, passing through loose bagged coke into the second compartment, where the water is again filtered through the same material before reaching the third compartment, where it is finally filtered before entering the feed tank.

A valve is fitted in the feed tank which is operated by a copper float to prevent air from entering the feed pipes. This valve may be operated by a lever on the outside of the tank. Each compartment in the filter tank is provided with a vapor pipe.

FEED PUMPS.

There are two main feed pumps in each engine room which draw water direct from the feed tanks or from the discharge of the hot-well pumps through the feed heaters. These pumps

have no other suction, and discharge into the main feed line only.

The auxiliary feed pumps are six in number and are located on the center-line bulkhead, one in each double fireroom. They draw from the feed tank, the sea, the boiler blow pipes, the main and auxiliary drains and the bilges in their respective compartments, and discharge into the auxiliary feed line, overboard or to the fire main.

Main feed pumps (four): Blake, simplex, vertical, center-packed plunger.	
Diameter of steam cylinders, inches	14
water cylinders, inches	10
piston rods, inches	2¼
Stroke, inches	18
Auxiliary feed pumps (six):	
Diameter of steam cylinders, inches	13
water cylinders, inches	9½
piston rods, inches	2¼
Stroke, inches	12

FEED-WATER HEATERS.

There is one feed-water heater in each engine room containing 950 square feet of heating surface. There are 852 tubes in each heater. Steam from the auxiliary exhaust line is bypassed into the heater and the back pressure is regulated by a spring relief valve. The hot-well pump takes water from the feed tank and delivers it through the tubes of the feed heater to the main feed-pump suction.

HOT-WELL PUMPS.

There is one hot-well pump in each engine room. This pump can drain water from the feed tank, the reserve double-bottom compartments and from the connections in the ship's side, where a hose may be connected for pumping out a water boat. The discharge is through the feed heater to the feed-pump suction, to the feed tank and also to the reserve tanks.

FIRE AND BILGE PUMP.

There is one fire and bilge pump in each engine room. These pumps draw from the sea, the drainage system and

from their respective bilges. They discharge into the fireroom or overboard.

Number and type of pumps: two F. and B. Blake, simplex, vertical, piston.

Diameter of steam cylinders, inches	12
water cylinders, inches	10
piston rods, inches	2¼
Stroke, inches	12

DISTILLER CIRCULATING PUMP.

There is one distiller circulating pump located in the evaporator room. This pump draws from the sea and delivers overboard or to the flushing main through the distillers or directly. By means of connecting valves the flushing main may be served by any pump discharging to the fire main.

AUXILIARY CONDENSERS.

There is one auxiliary condenser in each engine room and one in the lower dynamo room on the port side. These are of the well known Wheeler type, with air and circulating pump attached to and under the condenser.

FORCED-DRAFT BLOWERS.

There are sixteen Sturtevant blowers situated on the protective deck over the fireroom hatches and deliver directly into the boiler compartments. These blowers are encased, and from their excellent location give a most efficient service. They may be easily cared for and overhauled with ease, thus ensuring a long life and immediate readiness for service at all times.

FORCED DRAFT.

Number of blowers	16
Type of blower engines	Two-cylinder, vertical, double enclosed.
Seam cylinders (2) diameter, inches	6
Stroke, inches	5
Diameter of piston rods, inches	1⅛
fan, inches	66
Area of induction nozzle, square inches	1,385.45
eduction nozzle, square inches	1,728

THE GENERAL WORKSHOP.

Located on the berth deck over the evaporator room and extending athwartships to the width of the engine-room

hatches is the general worshop. The tools are driven by one ten-horsepower electric motor, and the usual counter shafting, belting and pulleys restrict the already limited head room.

The following tools are installed:

One 30-inch screw-cutting back-geared gap lathe, 10 feet between centers.

One 14-inch screw-cutting back-geared lathe, 4 feet between centers.

One column-shaping machine of 16-inch stroke and 26-inch traverse.

One back-geared drilling machine to drill up to 1½ inches and 14 inches from edge of work.

One 16-inch sensitive drill.

One No. 1 Universal milling machine.

One combined hand punch and shears,

One double-wheel emery grinder.

One 30-inch grindstone.

Six bench vices.

ASH HOISTS.

There are five ash-hoist engines, made by the Williamson Bros., of the usual servo-motor type, and are located in the fireroom hatches on the level of the gun deck. The buckets are hoisted through the ventilators to the main deck and trolleyed to the ash chutes at the sides.

DISTILLING APPARATUS.

There are four evaporators, arranged to be run in two pairs for double effect or each in single effect. There are two horizontal distillers in the evaporator room so arranged that the steam goes through the tubes. The rated capacity of the evaporators is 23,000 gallons of water per diem and that of the distillers is 10,000 gallons. This was met on the test by running all four evaporators in two double-effect pairs and distilling the water from the second-effect evaporator. This distilled water was measured, and exceeded the rated capacity of the distillers on a six-hour test.

ICE MACHINE.

There is supplied one 3-ton Allen dense-air machine. This is of the latest improved design, and showed excellent results on the tests. From the time of starting the machine, everything being at atmospheric temperature, the pressures were established in 45 minutes, one full batch of ice (135 pounds) was made in 3½ hours and the temperatures of the cold-storage rooms were reduced from 70 to 8, 14, 18 and 24 degrees, respectively, in six hours. In addition to this two scuttle butts, one on the deck above and one on two decks above, were cooled to 40 degrees.

ANCHOR WINDLASS.

There is a vertical Hyde steam windlass on the gun deck forward, the engine being located on the deck outside of the windlass house.

STEERING ENGINE

There is a Williamson Bros. combined hand-and-steam steering engine. The engine is controlled from the bridge, pilothouse and conning tower by a wire rope actuating the engine-valve and by a hydraulic telemotor to accomplish the same purpose.

TORPEDO OUTFIT AND AIR COMPRESSORS.

At the same time of writing this article the torpedo plant has not been fully settled nor installed. The vessels are to be provided with two submerged torpedo tubes, with the necessary compressors, and in connection with the compressors an additional air compressor will be installed to supply the smoke-blowing outfit.

SCREW PROPELLERS.

The propellers are of manganese-bronze and turn inboard when going ahead, the starboard propeller being left-handed. They are designed as true screws, and the surfaces of the blades are ground smooth and tinned for the *West Virginia* and not tinned for the *Maryland*. In smoothing the blades, no attempt was made to grind off the inequalities of the casting nor to fair the blade to a true helicoidal surface. On the run of the *West Virginia* to Boston it was found that the port

engine averaged about 3 to 4 revolutions less than the starboard, and the vessel carried a port helm of about one degree. On the speed trial the average difference was 4.45 revolutions per minute. There was also a difference in the horsepower, the port engine developing 1,502.7 I.H.P. more than the starboard. This was due to the use of steam in the P.L.P. receivers in order to try and bring up the revolutions of the port engine to those of the starboard.

On the return from the trial to the shipyard the vessel was docked and the pitch of the screws remeasured. It was found that the port screw showed about six inches more pitch than the starboard, and this may have been due to faulty measuring, or the blades may have been sprung when first backing away from the dock by catching a heavy rope cable around the port screw.

Taking the average revolutions on the trial and the pitch as remeasured, the starboard engine drove the vessel 2,118 feet more in an hour than the port (this is neglecting the slip of both wheels), and this accounts for the port helm. The port wheel was reset to correspond with the starboard.

In order to avoid any difference in the two wheels of the *Maryland* and to set each blade to correspond with all others, the question of measuring the pitch and setting the blades was taken up personally by the author, and he, in company with Mr. A. A. Howitz, one of the leading engine draftsmen of the company, very carefully set each blade at a pitch of 22 feet and 6 inches at a radius of 6 feet 6 inches. The pitchometer used was somewhat crude, but of sufficient accuracy to make all errors constant, as was tested by remeasuring a blade that had been removed from the hub and replaced in the marks, when it was found that the pitch was the same as before. The contractors remeasured the blades by laying the propellers on a planer bed and measuring from the horizontal surface. These measurements showed the port propeller to be as before set, but that the starboard propeller was not as high. The pitch of this wheel was increased to bring it up to the port wheel as measured when on the bed plate, and remeasured by

means of a pitchometer for use when the plane of rotation is horizontal. After a dock trial, it was claimed that the starboard engine ran faster, with less power, than the port, and the contractors reset the starboard propeller to agree with certain shop marks furnished from the pattern, and the pitch of both wheels was reported to the Board of Inspection to be 22 feet 6 inches.

Number of blades	3
Diameter, feet and inches	17- 3
of hub, inches	54
Length of hub, inches	42
on official trial, *West Virginia*, mean, ft. and ins...	22-044
Maryland, mean, ft. and ins.....	22- 6
Helicoidal area, square feet	83.7
Disc area, square feet	240.53
Pitch ÷ diameter, *West Virginia*.....	1.275
Maryland	1.304

ELECTRIC PLANT.

The electric plant of these vessels (and their class) is the largest of any heretofore installed in any vessel of the United States Navy.

There are three 100-kilowatt and four 50-kilowatt generating sets, all at a pressure of 125 volts.

All of the auxiliary machinery in the different compartments outside of the engine and fire rooms, except the anchor windlass, the forced-draft blowers, and the steering engine, is actuated by electric motors.

The dynamo rooms are immediately forward of the boiler compartments, and the generators take steam directly from the auxiliary steam pipes.

The lighting output supplies 1,200 incandescent 16-candlepower lamps, 1,329 incandescent 5-candlepower lamps for use in the battery-control instruments, 14 5-ampère arc light (about 500-candle power each), one in each fireroom and two in each engine room. There are 6 30-inch hand-controlled searchlights of 21,000 candlepower each.

There are in all 103 separate electric motors, the principal ones being—

		Horsepower.
2	Torpedo air-compressor motors (40 each),	80
2	Boat-crane motors (35 each),	70
7	Deck-winch motors (25 each),	175
2	Boat-crane motors (20 each),	40
2	Turret-turning motors (15 each),	30
1	Workshop motor (10),	10

In addition to the above there are 46 small fan motors, two night-signalling sets, and 6 portable ventilating sets.

The total horsepower of the electric plant is about 670 I.H.P., or 2⅓ per cent. of the total horsepower at full speed.

DYNAMO ENGINES.

Type	Cross compound
50-kw. dynamo engines, number	4
Diameter of cylinder, H.P., inches	7½
L.P., inches	14
Stroke, inches	8
Diameter of piston rods, H.P., inches	1¾
L.P., inches	1¾
100-kw. dynamo engines, number	3
Diameter of cylinders, H.P., inches	10
L.P., inches	18
Stroke, inches	10
Diameter of piston rods, H.P., inches	2¼
L.P., inches	2¼

BOILERS.

There are sixteen Babcock and Wilcox boilers of the latest improved type. The arrangement of drums, baffling and circulation, is shown in the cut, reproduced from an article by Lieutenant R. K. Crank in the previous issue of the JOURNAL, and to which article the reader is referred for a full description of the boilers of this vessel:

BOILER DATA.

Floor space, length, feet and inches	9- 1½
width, feet and inches	16- ½
Length of grate, feet and inches	7- 0
Width of grate, feet and inches	7- 1½
Grate surface, one boiler, square feet	100
all boilers, square feet	1,600
Heating surface, one boiler, square feet	4,434

Heating surface, all boilers, square feet	70,944
to grate surface	44.34
Number of tubes in one boiler (2-inch, 901; 4-inch, 57)	923
elements, one boiler	27
Weight of water in one boiler at steaming level, pounds	15,750
one boiler complete, pounds	89,068

VENTILATION.

On these ships all the spaces below the gun deck, and the officers' and crew's closets on the gun deck, are provided with artificial ventilation. There are sixteen systems (or units) of ventilation, and these are grouped into four methods, viz:

The supply and exhaust method.—This method is applied to all compartments where it is difficult both to supply the fresh air and to exhaust the foul by natural convection. Under this head come the dynamo rooms and steering-engine room.

The supply method.—Air is supplied by forced ventilation to all compartments below the gun deck and between the 'thwartship armor bulkheads, and also, where necessary, as in the magazines, exhaust ducts are provided to allow the escape of the foul air.

The exhaust method.—Where there is a natural inlet of fresh air through hatches and air ports, as in the case of living quarters forward and aft on the berth deck, the foul air is exhausted by fans.

The convection method.—This is applied to the bunkers and firerooms where there is a natural flow of heated air upward through hatches and pipes provided for that purpose and ventilators and supply pipes are arranged to carry the fresh air to supply the need.

The engine-room ventilation is very successfully planned. There are four electric blowers located on the gun deck and supply fresh air from ventilators to the four large ducts leading inboard and outboard in each engine room. From these ducts branches are led to the various points in the engine rooms where cool and fresh air is most needed, and from the various tests it is believed that a fairly cool and even temperature will be kept even in the hottest climate.

THE SPEED TRIAL OF THE *WEST VIRGINIA.*

The *West Virginia* left her anchorage off the shipyard at Newport News at 12·05 P. M. of October 29, 1904, having on board 517 officials, observers and crew. Of this number 315 were in the Engineer's department, 109 in the chief steward's department, 10 representatives of sub-contractors and 25 representatives of the Government, including enlisted men who were to serve on this vessel in commission.

There was on board 1,960 tons of coal (402 in bags), 5,495 gallons of oil and 958.35 tons of fresh water. The run to Boston was made without mishap and the vessel was anchored in President's Roads early on the morning of the 31st.

On the morning of November 2 the start was made for the Cape Ann trial course, and the vessel was run over the course and return with the following performance:

SYNOPSIS OF STEAM LOG.

West Virginia.

Steam pressure at boilers (gauge), pounds	274.1
H.P. steam chest, S. engine (gauge), pounds	236
P. engine (gauge), pounds	236
first receiver, S. engine, absolute, pounds	99
P. engine, absolute, pounds	104.2
second receiver, S. engine, absolute, pounds	47
P. engine, absolute, pounds	50.9
Vacuum in condensers, in inches of mercury, port, 26.5; starboard,	26
Mean effective pressures in cylinders, in pounds, per square inch:	
Main engines, starboard, H.P	107.8
I.P	32.56
F.L.P	18.04
A.L.P	19.56
port, H.P	107.3
I.P	32.53
F.L.P	26.3
A.L.P	26.27
Mean pressure in pounds per square inch on L.P. piston, equivalent to aggregate M.E.P. on all pistons, starboard	44.96
Mean pressure, in pounds per square inch, on L.P. piston, equivalent to aggregate M.E.P. on all pistons, port	54.2
Revolutions per minute:	
Main engines, starboard, 129.7; port,	125.25
Pumps, air, starboard, 35.6; port,	27.3
circulating, starboard, 164.6; port,	177.35
Main feed, double strokes per minute, starboard, 20.8; port,	27.3
Pumps, auxiliary, fire and bilge, starboard, 46.1; port,	46.5

Speed of ship in knots per hour	22.146
Slip of propeller in per cent. of its own speed, based on mean pitch.....starboard, 21.35; port,	18.56
Air pressure in firerooms, in inches of water	1.87
Indicated horsepower:	
Main engines, starboard H.P.	3,847.8
I.P.	3,213.5
F.L.P.	2,423.1
A.L.P.	2,627.3
total	12,111.7
port, H.P.	3,694.1
I.P.	3,101.8
F.L.P.	3,412.7
A.L.P.	3,408.8
total	13,614.4
Air pump.....starboard engine, 23.46; port engine,	15.06
Circulating pump.....starboard engine, 52.2; port engine,	68.6
Feed pumps, main (four)	137.52
auxiliary (six)	83.65
Fire and bilge pumps (two)	10.77
Hotwell pumps (two)	28.24
Distiller circulating pump (estimated)	14
Dynamo auxiliary-condenser circulating pumps	2.034
Blower engines for forced draft in firerooms (sixteen)	219.84
Dynamo engines	86.13
Collective of both main engines	25,726.1
main engines, air, circulating, hot-well and feed pumps	26,134.83
main and auxiliary engines in operation during trial	26,465.57
all machinery during trial, per square foot of G. S.	16.54
H. S.	.373
Main engines, air, circulating and feed pumps, per square foot of G. S.	16.33
Main engines, air, circulating and feed pumps, per square foot of H. S.	.368
Coal: kind and quality.....Bagged hand-picked New River.	
pounds per hour	80,389
pounds per hour per I.H.P. collective, all machinery in operation	3.037
pounds per hour per square foot of G. S.	50.24
H. S.	1.12
Cooling surface, square feet per I.H.P.	1.08
Heating surface, square feet per I.H.P.	2.68

PUMPS IN THE ENGINE ROOMS.

Number and type of pumps.....Two hot-well, Blake simplex, vertical piston.	
Diameter of steam cylinders, inches	12
water cylinders, inches	16

Diameter of piston rods, inches	2¼
Stroke, inches	16

AUXILIARY CONDENSERS.

	(*a*) *Engine Room.*	*Dynamo.*
Cooling surface, each, square feet	601.4	1,200.9
Diameter of steam cylinders of pump, inches	8	12
circulating pump cylinder, inches	10	14
air-pump cylinder, inches	10	14
Stroke, common, inches	12	12
Air pump, kind of valves	Hard rubber.	

After the test of the helm the speed was slacked until the steam pressure was under control, and the following practical trials were made: (*a*) With the engine stopped, the vessel having been brought to a dead still position, head to wind and helm amidship, the starboard engine was started at full speed astern and the port engine at full speed ahead. The time of turning through 360 degrees was 14 minutes and 23 seconds. (*b*) The same trial was made with the engines reversed: time, 13 minutes and 37 seconds.

This compares most favorably with the *Colorado*, which is fitted with out-turning screws, and occupied 15 minutes 51⅘ seconds on trial (*a*) and 15 minutes on trial (*b*).

The coal used on the run to and from Boston was estimated at 520 tons each way. There were 4,335 gallons of oil used on the whole round trip, and 1,300 pounds of tallow. Of the fresh water carried, 211 tons were used on trip to Boston—65.7 tons on the trial run and 226.3 tons on the return trip. This does not include the water used in Boston, nor does it include any water used for other than engine and boilers. An increase of reserve-feed supply from 150 tons to 275 tons was recommended by the Trial Board.

TRIAL OF U. S. S. *MARYLAND*.

The *Maryland* left Newport News at 11·25 A. M., on January 21st, 1905, and arrived at Boston, Mass., at 12·43 A. M., on January 23d.

The draught on leaving was taken before heaving in, and was 24 feet 4½ inches forward, and was 26 feet 4 inches aft.

In order to obtain better results on this vessel than her sister, the contractors installed an electric device for signalling the periods of firing the furnaces. This device consisted of a motor and gearing arranged to make a contact on a lighting circuit at regular intervals. The gears gave six different changes, and by regulating the speed of the motor any desired interval could be obtained. The firemen were, with few exceptions, brought from New York just before the ship left Newport News, and showed little or no training in handling fires to produce economy in consumption of coal. The regularity of firing, however, showed its results in the ability to carry a higher pressure of steam, in a greater horsepower and increased speed.

In order to obtain data for working the machinery on the official trial the following tests were made on the run north:

TEST A.—NO STEAM IN RECEIVERS.

	Starboard.		*Port.*	
Revolutions per minute	119		118	
Main steam	270		273	
Vacuum	28.2		26.1	
H.P. valve chest	245		233	
First receiver	80		81	
Second receiver	18		15.5	
I.H.P., H.P. cylinders	3,810		3,480	
L.P. cylinders	4,075		3,980	
F.L.P. cylinders	1,817	3,877	1,747	3,522
A.L.P. cylinders	2,060		1,875	
	11,762		11,082	
Total I.H.P. (engines only)				22,844

TEST B.—STEAM FIRST RECEIVER ONLY.

	Starboard.		*Port.*	
Revolutions per minute	126		126	
Main steam (gauge)	268		270	
Vacuum	26		26	
H.P. valve chest	257		257	
First receiver	105		108	
Second receiver	25		22	
I.H.P., H.P. cylinders	3,605		3,655	
I.P. cylinders	5,300		5,275	
F.L.P. cylinders	2,475	4,963	2,180	4,690
A.L.P. cylinders	2,488		2,510	
Total I.H.P.				27,488

TEST C.—STEAM IN FIRST AND SECOND RECEIVERS.

	Starboard.		*Port.*	
Revolutions per miuute	126		126	
Main steam	249		250	
Vacuum	26.5		26.6	
H.P. valve chest	242		240	
First receiver	102		103	
Second receiver	28		29	
I.H.P., H.P. cylinders	3,440		3,272	
I.P. cylinders	4,810		4,730	
F.L.P. cylinders	2,576	5,364	2,892	5,982
A.L.P. cylinders	2,788		3,090	
Total				27,598

TEST D.—STEAM IN SECOND RECEIVER.

	Starboard.		*Port.*	
Revolutions per minute	123		122.5	
Main steam	257		265	
H.P. valve chest	248		245	
First receiver	85		85	
Second receiver	27		26	
I.H.P., H.P. cylinders	4,278		4,110	
I.P. cylinders	3,711		3,380	
F.L.P. cylinders	2,411	5,086	2,810	5,562
A.L.P. cylinders	2,675		2,752	
Total				26,117

Before the vessel left Newport News additional vacuum gauges were fitted by direction of the Bureau of Steam Engineering at various points in the exhaust line, condenser and air-pump suction. The following table gives the reading of these gauges during the different tests shown above:

READING OF VACUUM GAUGES.

	TEST A.		TEST B.	
	Star.	*Port.*	*Star.*	*Port.*
Air-pump suction	27.2	27.2	25.4	26.8
Bottom of condenser	25.6	27.2	25.8	25.8
Top of condenser	26.5	26.7	24.7	23.7
F.L.P. exhaust, forward end	28.1	25	23.8	21
after end	24.2	23.7	21.3	19.9
A.L.P. exhaust, after end	28	28	21.9	22
forward	24.8	24.5	21.9	20.6

SYNOPSIS OF STEAM LOG.

Steam pressure at boilers (gauge), pounds	278.2
H.P. steam chest, S. engine (gauge), pounds	250.5
P. engine (gauge), pounds	246.5

Steam pressure at first receiver, S. engine (absolute), pounds	126.75
P. engine (absolute), pounds	122.
second receiver, S. engine (absolute), pounds	48.5
P. engine (absolute), pounds	47.5
Vacuum in condensers, in inches of mercury, port, 25.3 ; starboard,	25.8
Mean effective pressures in cylinders, in pounds, per square inch :	
Main engines, starboard H.P	89.06
I.P	42.
F.L.P	23.48
A.L.P	25.5
port H.P	81.19
I.P	45.19
F.L.P	24.72
A.L.P	25.23
Mean pressure in pounds per square inch on L.P. piston, equivalent to aggregate M.E.P. on all pistons, starboard	51.76
Mean pressure in pounds per square inch on L.P. piston, equivalent to aggregate M.E.P. on all pistons, port	52.361
Revolutions per minute :	
Main engines ..... starboard, 127.72 ; port,	127.96
Pumps, air ..... starboard, 27.36 ; port,	37.6
Circulating ..... starboard, 174.5 ; port,	182.9
Pumps, main feed, double strokes per minute, starboard, inboard	21.9
outboard	23.9
port, inboard	23.
outboard	21.
auxiliary, fire and bilge ..... starboard, 48.4 ; port,	47.5
Speed of ship in knots per hour	22.406
Slip of propeller in per cent. of its own speed, based on mean pitch ..... starboard, 20.99 ; port,	21.15
Air pressure in firerooms, in inches of water	1.93
Indicated horsepower :	
Main engines, starboard H.P	3,131.6
I.P	4,081.7
F.L.P	3,106.
A.L.P	3,373.2
total	13,692.5
port H.P	2,860.
I.P	4,399.6
F.L.P	3,276.1
A.L.P	3,343.1
total	13,878.8
Air pump ..... starboord engine, 16.12 ; port engine,	18.008
Circulating pump ..... starboard, 66.09 ; port,	77.14
Feed pumps, main (four)	174.
auxiliary (four)	133.6
Fire and bilge pumps ..... starboard, 2.2 ; port,	0.2
Hot-well pumps ..... starboard, 9.95 ; port,	11.92

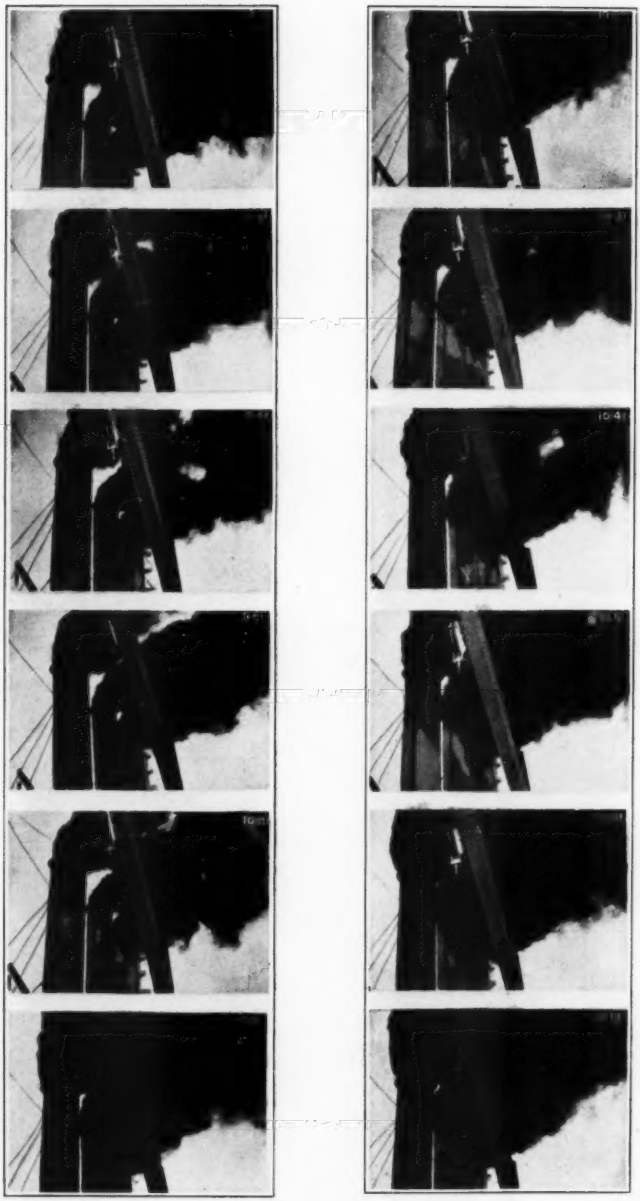
Indicated horsepower:	
Circulating pump (estimated), flushing	4.5
Blower engines for forced draft in firerooms (sixteen)	352.
Dynamo engines (one)	56.57
Collective, both engines, main	27,571.3
main engines, air, circulating, hot-well and feed pumps	28,058.95
main engines and all auxiliaries in operation during trial	28,474.42
all machinery during trial, per square foot of G.S.	17.79
main engines, air, circulating, hot-well and feed pumps, per square foot of G.S.	17.536
main engines, air, circulating, hot-well and feed pumps per square foot of H.S.	0.3955
Coal, kind and quality, bagged, hand-picked New River, pounds per hour	81,148.2
Pounds per hour per I.H.P. collective, all machinery in operation	2.849
Pounds per hour per square foot of G.S.	50.74
H.S.	1.144
Cooling surface, square foot per I.H.P.	1.012
Heating surface, square foot per I.H.P.	2.492

The *Maryland* carried 2,010 tons of coal, 687.38 tons of fresh water for steaming purposes, 5,298 gallons of oil and 287.4 tons of fresh water for ship's use.

On the run from Cape Charles lightship to Winter Quarter Shoal lightship, a distance of 57 knots, the ship showed:

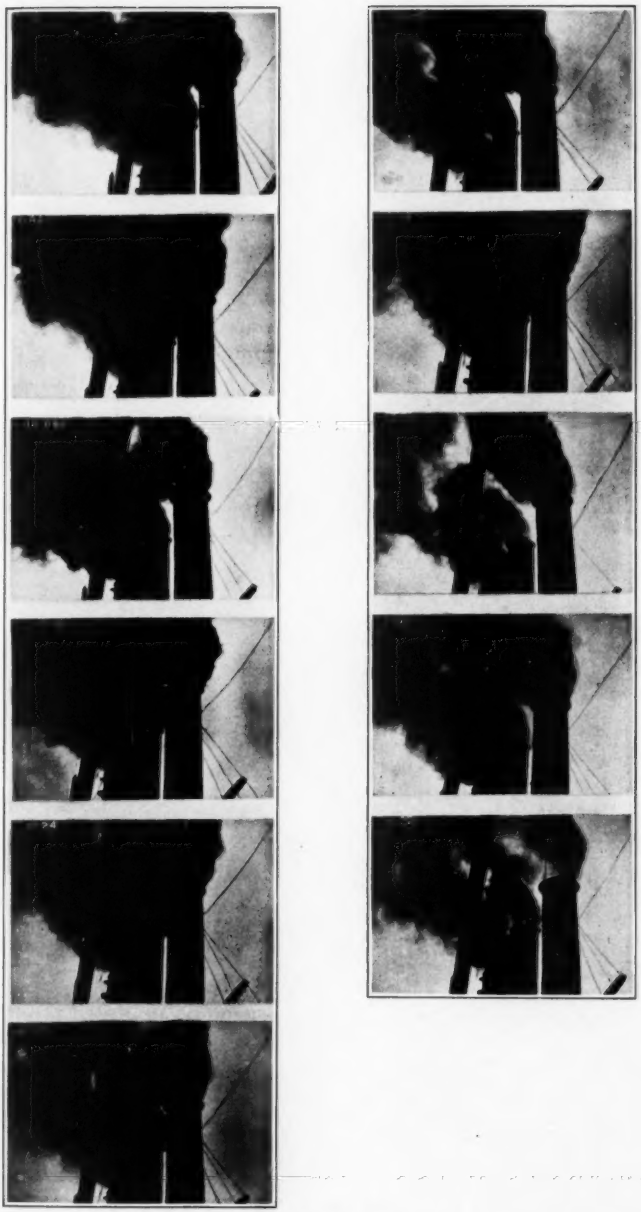
Revolutions per minute	99.5
Steam (main gauge)	262.6
Vacuum	28.2
Speed (average)	17.58
Slip, per cent	20

Just after starting on the trial course the discharge air chamber of the port hot-well pump broke, and this pump had to be temporarily stopped. This necessitated the use of feed direct from the feed tank without passing through the feed heater. The sea was quite rough for the first fifteen knots, and the steering was not as straight as might have been, owing to the previous bad weather setting the buoys away. When this is taken into consideration, the *Maryland's* speed of 22.406 will place her at the top of the class.



U. S. S. "MARYLAND."

Photographs of Smoke taken at ten-minute intervals during trial. Run North.



U. S. S. "MARYLAND."

Photographs of Smoke taken at ten-minute intervals during trial. Run South.

REPORTS ON TESTS OF A CENTRIFUGAL PUMP AND A "SIROCCO" BLOWER DRIVEN BY DE LAVAL STEAM TURBINES.

1. The undersigned, having been appointed to make certain tests on a centrifugal pump as built by the De Laval Steam Turbine Company and a blower of the "Sirocco" type, both driven by De Laval Steam Turbines, together with steam consumption tests of the turbines, have the honor to submit the following reports:

2. The tests in question were conducted on November 30, December 1 and 2, 1904, in the testing room of the De Laval Steam Turbine Company's Works at Trenton, N. J., and were carried out with an object to determine the following items:

BLOWER.

1. The quantity of air delivered, corresponding pressures and revolutions per minute.
2. The air horsepower (A.H.P.).
3. The efficiency for normal and reduced output.

PUMP.

1. The quantity of water discharged, corresponding heads and revolutions per minute.
2. The water horsepower (W.H.P.).
3. The efficiency for normal and reduced output.

TURBINES.

1. Brake horsepower (B.H.P.).
2. Steam consumption per brake horsepower.
3. Their suitability in connection with pumps and blowers.

3. In explanation of remarks, possibly prompted by the comparatively narrow range within which these tests were carried out, it is necessary to mention that, owing to the time consumed

in mounting the pump and blower separately, as well as disconnecting and fitting up for the brake tests and the demand upon the testing room for other tests of commercial importance, only such tests were made which would convey general information with regard to the adaptability for naval purposes of such pumps and blowers when driven by turbines.

DESCRIPTION OF APPARATUS.

4. Turbine-driven pumps and blowers being of comparatively recent application, none as yet having been installed in any ship of the Navy, the following short description of the machinery involved, and especially of the turbines, will be of interest.

5. The blower was of the "Sirocco" type, cased fan, of 20 inches diameter, double inlet, discharging on the side, mounted on a common bedplate with the turbine (Figs. 1 and 2). The turbine shaft was geared into one other shaft, to which the blower shaft was connected by a coupling driving the blower at one-tenth the number of revolutions of the turbine wheel.

6. The pump was of the centrifugal type, composed of two entirely independent pump casings with impellers, mounted with the turbine on a common bedplate (Fig. 3). The turbine shaft was geared into two other shafts, each one separately driving a pump. There was one suction and one discharge pipe for the two pumps, the discharge pipe of the first pump being connected directly to the suction pipe of the second pump, the size of the common pipe, 15 inches diameter, being that required by each pump separately. This arrangement of pumps is termed by the builders a centrifugal series pump, and is especially adapted where an extreme lift is required. It is, of course, readily understood that each pump may have an independent suction and discharge pipe, the system arranged in that way being called parallel-connected, discharging twice the quantity of water but against only one-half the head, the driving power in both cases being the same.

7. The De Laval steam turbine, Fig. 4, as is well known, is of pure impulse type, and consists of one single disc with one

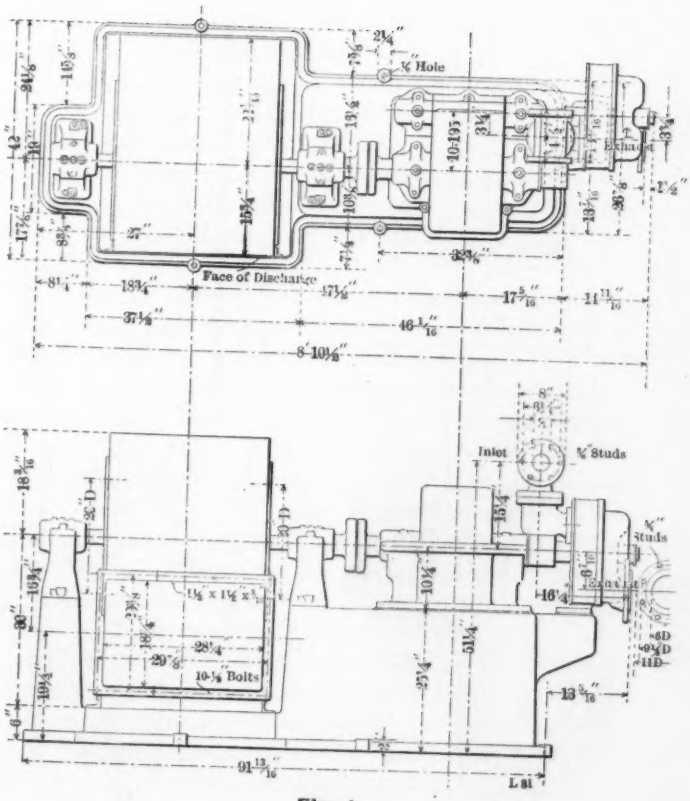

¾" Hole
Face of Discharge
Inlet
¾" Studs
¾" Studs
1½ x 1½ x ½
10-⅛ Bolts
Exhaust
Base

Fig. 1.

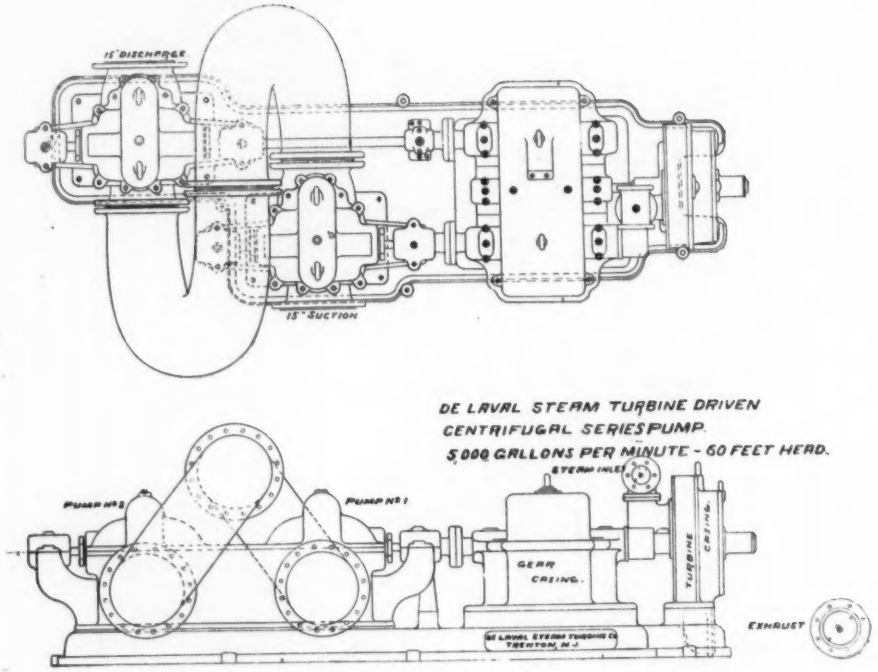

15" DISCHARGE
15" SUCTION
DE LAVAL STEAM TURBINE DRIVEN
CENTRIFUGAL SERIES PUMP.
5,000 GALLONS PER MINUTE - 60 FEET HEAD.
STEAM INLET
PUMP No 2
PUMP No 1
GEAR CASING.
TURBINE CASING.
EXHAUST
DE LAVAL STEAM TURBINE CO.
TRENTON, N.J.

Fig. 3.

row of vanes, against which steam impinges at a very high velocity as a result of expansion in diverging nozzles. These nozzles have their seating in a ring-shaped steam chamber, situated on the one side of the wheel with the exhaust chamber on the other, and are closely placed, occupying nearly the whole of the circumference. Each nozzle is controlled by a valve and hand-wheel independently.

8. The range of power is considerable, an increase or decrease in the amount of steam admitted to the wheel being governed by the number of nozzles open. The nozzles are proportioned with reference to the rotative speed of the turbine, and are made for either condensing or non-condensing conditions, the change being performed without a great deal of trouble.

9. The rotative speed of the wheel is kept constant for a variation in the load by a throttling device actuated by a centrifugal governor.

10. The gears of transmission consist of a spiral spur pinion made of high-grade, high-carbon nickel-steel, which engages either one or two spiral gears, as conditions may require. This depends largely on whether the power is wanted on one (as in the blower) or on two (as in the pump) shafts, but also on the size of the machine, the large machines invariably having double gears. The pinion is made solid with the turbine shaft, but the gears are built up of cast-steel pulleys with soft steel rings, of low carbon, shrunk on the rims.

11. The teeth are cut with perfect accuracy, resulting in almost noiseless motion, combined with great durability. Both pinion and gears are made in pairs, having the teeth inclined in opposite directions, thereby preventing distortion, due to the pressure of the gear itself, or to unequal thrust on the vanes, should such exist.

12. The main bearings are ring oiling, the oil being fed from a common reservoir placed at a convenient point and at some distance above the center of the shaft. The drip oil from the drain troughs is collected in a closed receptacle placed at the base and is under condenser pressure. No oil is used

within the turbine itself, and, therefore, no oil exists in the exhaust steam.

13. Although rotating at an extremely high number of revolutions, there was but slight vibration, and only such noise as made by steam, water or air when flowing through pipes at a high velocity.

14. A feature of special interest are the coupling bolts and their connection to the couplings. The bolts are made of steel, but do not bear direct on the metal of the holes in the couplings, a rubber sleeve with a steel bushed hole of a slightly larger diameter than the bolt make up the combination. This is presumably done to reduce shock that may be effected by the rapid starting of the turbine wheel.

15. Superior workmanship, in connection with the use of high-grade materials, make this motor rank with the best, and, so far as known, its durability compares favorably with other motors, while its operation is marked by simplicity.

16. Its economic standard with regard to steam consumption may be judged from results obtained in the tests hereinafter referred to as well as numerous other tests made from time to time.

METHOD EMPLOYED TO MEASURE STEAM CONSUMPTION.

17. All De Laval steam turbines, unless specially ordered, are supplied with two independent sets of nozzles, one set being used when running condensing, the other when non-condensing, the number of nozzles in use being governed by the horsepower required.

18. Numerous experiments performed with De Laval nozzles having proved that only a certain amount of steam passes through the nozzle per unit of time for given conditions of pressure, vacuum and quality of steam, it was concluded that the apparatus used by the builders for the determination of steam consumption was sufficiently reliable. In one of its details this apparatus consisted of a pipe containing a nozzle of identical dimensions as those used in the turbine (condensing or non-condensing, as the case may be), the steam flow to

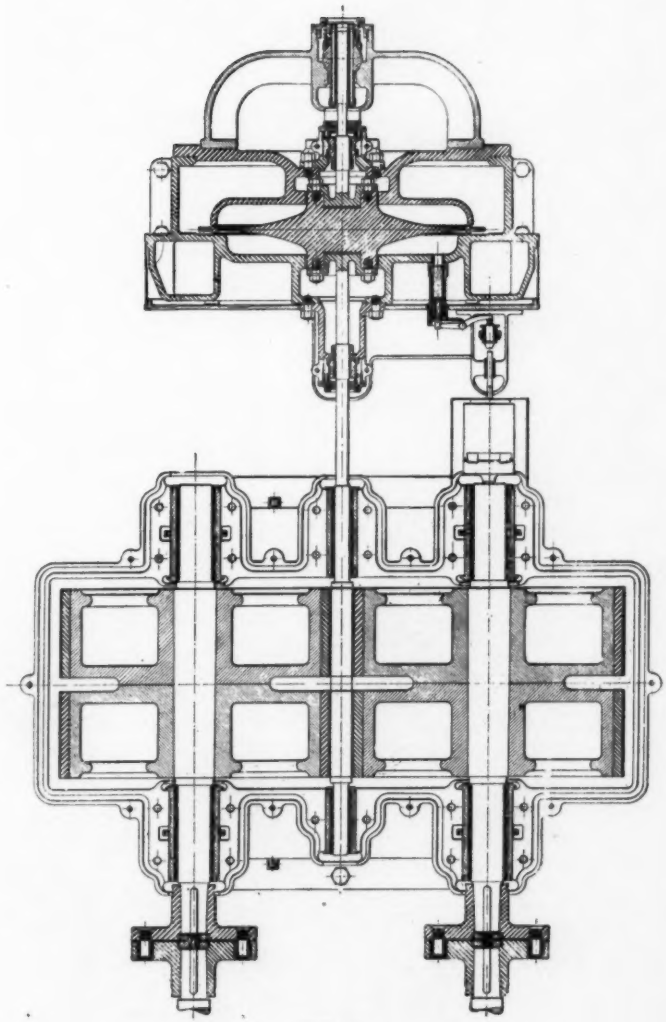


Fig. 4.

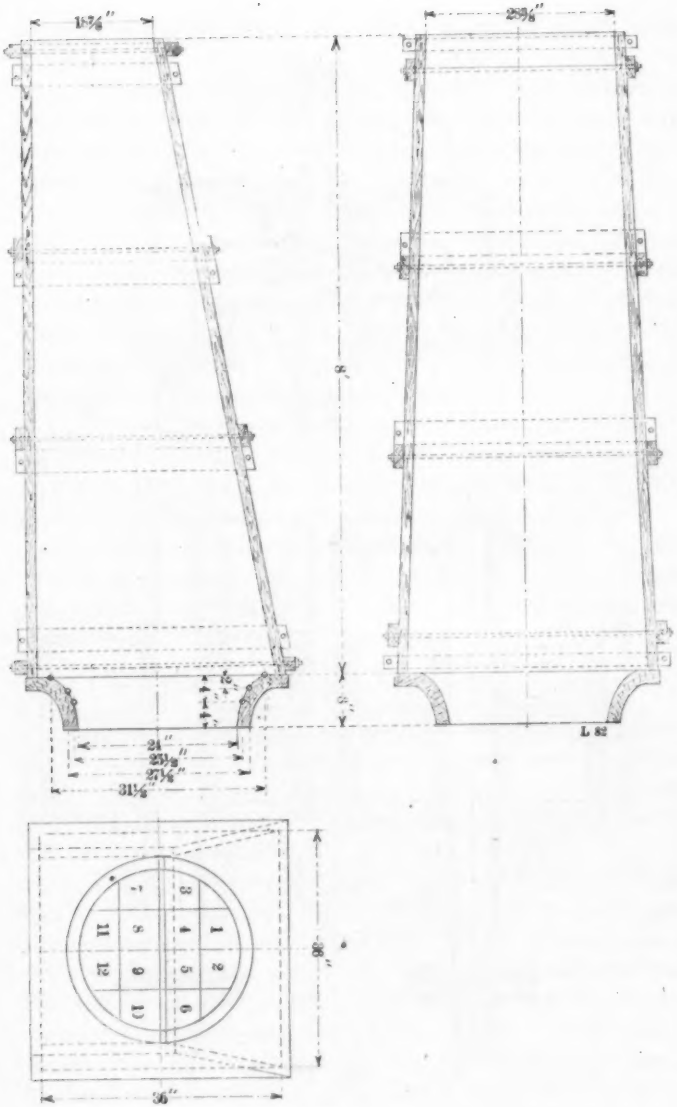


Fig. 6.

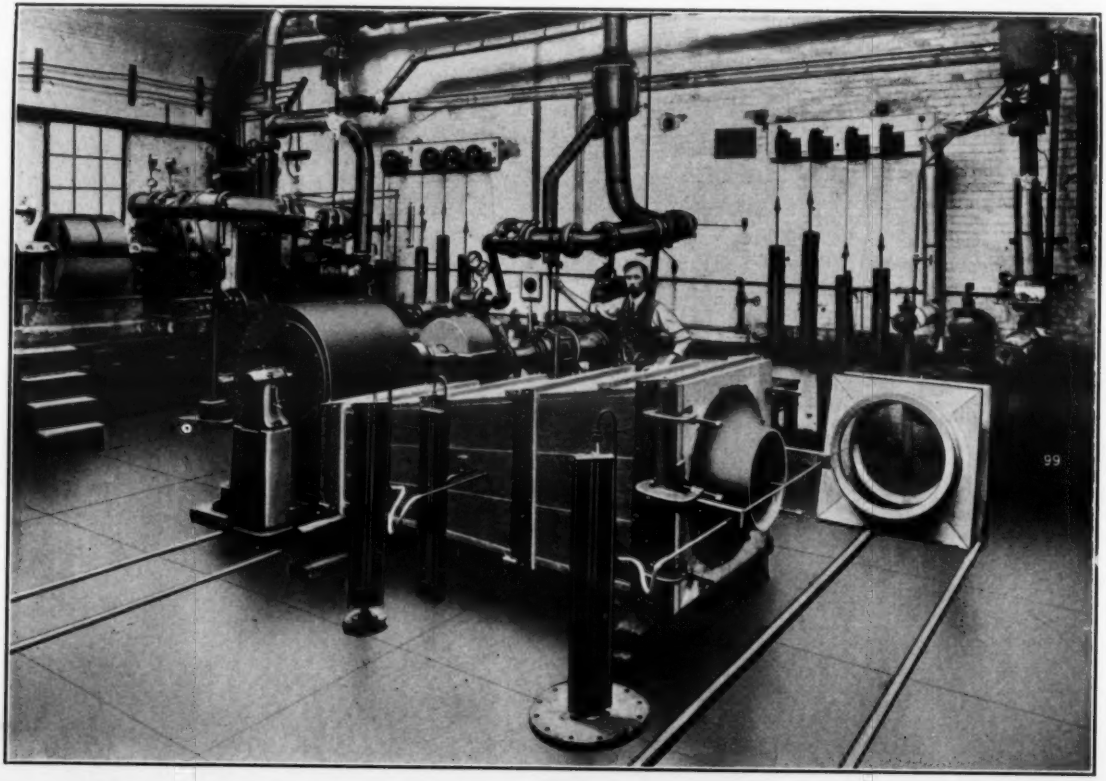


Fig. 2 and 5.

it from the turbine casing being regulated by a three-way valve. The discharge end of the pipe was furnished with a perforated conical cap, and was located near the bottom of the condenser, consisting of a barrel containing water, placed on a scale. A steam gauge was placed between the nozzle and the barrel to ascertain with certainty that the pressure on the discharge side of the nozzle in no case exceeded 58 per cent. of that on the steam side, thus satisfying the condition for maximum discharge from a nozzle. In no case did this pressure rise to even nearly 58 per cent. The three-way cock was set immediately before each test to discharge all condensed steam in the pipe into the atmosphere, then quickly turned to admit the steam into the barrel. The time of admission, ranging between one and three minutes, was carefully noted, and the weight of the water in the barrel was taken before and after the discharge. The difference in these weights gave the total steam taken by the turbine by each nozzle for the time the nozzle was open. This is given in the tabulated data for each test separately, the total amount of steam used per hour being obtained by multiplying the quantity passed through test nozzle by the number of nozzles in operation into the ratio of sixty and the time it was open.

TEST OF SIROCCO BLOWER.

19. The blower in question was specially ordered for this test, and made to dimensions such that its output would conform to conditions required for the machinery installation of the three new scout ships, *Salem*, *Birmingham* and *Chester*. Under these requirements there must be delivered to each boiler room 56,000 cubic feet of air per minute furnished by one or two blower units, and a pressure of 5½ inches maintained.

20. The usual method of discharging the air from the blower into an air-tight receptacle was also employed in these tests, and is shown in Fig. 5.

21. At the outlet end of the plank box, shown in detail on

Fig. 6, was fitted a converging nozzle of suitable proportions, with entrance line well rounded. The velocity head of the outflowing air was ascertained with a Pitot tube of $\frac{3}{32}$ inch diameter, the average for the whole nozzle being arrived at by measuring the velocity at different points of the orifice. These readings were obtained with accuracy by the following simple method:

22. The section at the outlet of the nozzle was divided in spaces, six inches square, by stretching fine wire across the orifice, and then, by recording the reading as obtained in the center of each square, the mean of all readings was taken, giving an average velocity head for the whole nozzle.

23. The pressure was ascertained by inserting in the box at each side tubes connected to syphon gauges. These tubes were furnished with bell-shaped mouth pieces, having their faces parallel to the flow of the air, and the readings were therefore not influenced by the velocity. Other Pitot-tube observations were made at about the middle of the box for three equidistant points. The temperature of the air in the box was taken near the compression gauge.

24. After completion of blower tests the blower was disconnected and brake tests of turbine performed, Fig. 7. This was done by connecting a Prony brake to the gear shaft and then by loading the lever until the steam gauge below the governor valve registered approximately the same pressure as during any one of the blower tests. The speed of the turbine as well as the number, etc., of nozzles open were adjusted to conform with conditions during the blower tests. Steam consumption was obtained in the manner previously described for the blower.

25. Tabulated results of various readings and observations will be found on Table I; results relating to steam consumption and other items for derivation of efficiency on Table II; calibrations of gauges on Table III.

Test "A" comprises blower performance at about 1,500 R.P.M., condensing (normal).

Test "B", same at about 1,000 R.P.M., condensing.

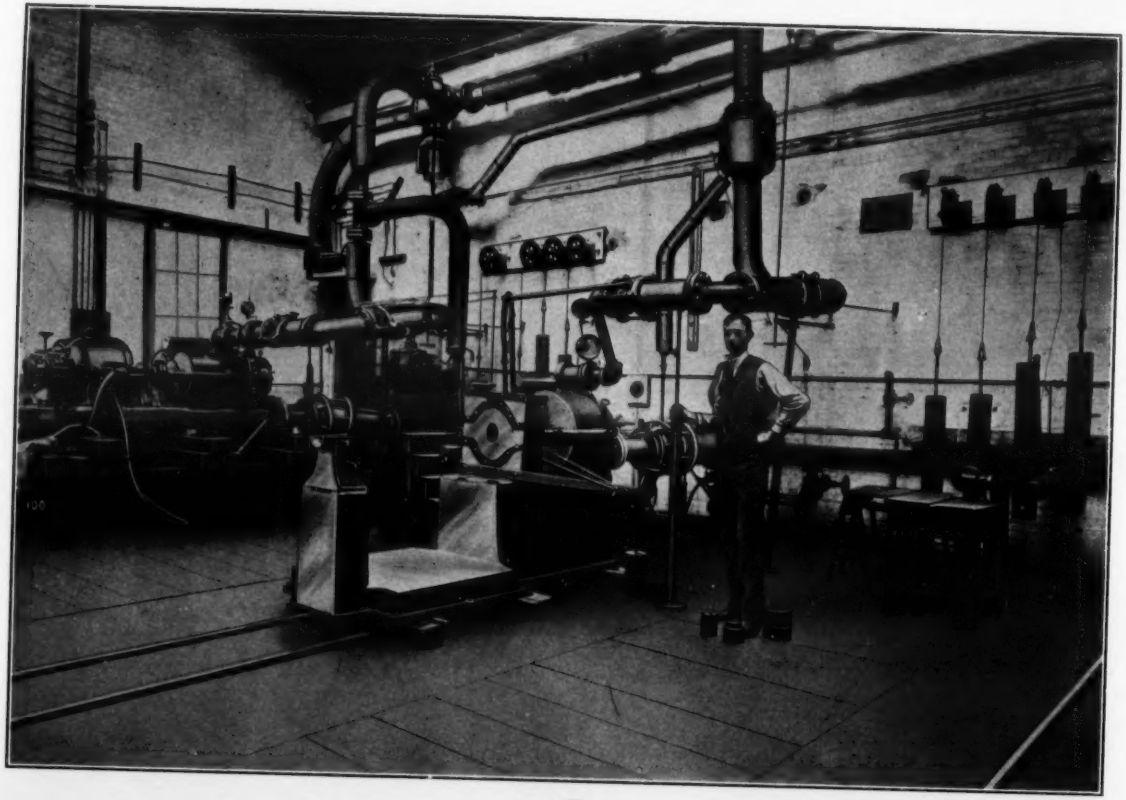


Fig. 7.

TABLE I.

SIROCCO BLOWER TESTS.

Readings of Temperature, Barometer and Pressure in Air Box and at Pitot Gauge (inches of water).

Blower.	Test.	Number of test.	Time of test, year, 1904. Day	Hour.	Pitot tube in air box at three points. I*	II	III	Pitot tube at orifice of air box; readings taken at center in squares as designated in Fig. 6. 1	2	3	4	5	6	7	8	9	10	11	12	Compression in air box at three points. I*	II	III	Inlet to air box. Temp. air deg. C.	Press. ins. water.	Psychrometer. Deg. F. Wet	Dry	Barometer.
	A	1	November 30.	12'00	$6\frac{3}{4}$	$5\frac{3}{8}$	$6\frac{1}{4}$	$6\frac{1}{2}$	7	$6\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{1}{2}$	$6\frac{5}{8}$	$6\frac{1}{2}$	$6\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{7}{8}$	7	$4\frac{5}{8}$	$4\frac{1}{2}$	$4\frac{5}{8}$	30	$4\frac{7}{8}$	65	77	29.86
		2		12'10	$6\frac{3}{4}$	$5\frac{7}{8}$	$6\frac{1}{8}$	$6\frac{1}{2}$	$6\frac{7}{8}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{5}{8}$	$6\frac{1}{2}$	$6\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{7}{8}$	7	$4\frac{5}{8}$	$4\frac{1}{2}$	$4\frac{5}{8}$	30	5	66	77	
		3		12'20	$6\frac{5}{8}$	$5\frac{3}{4}$	$6\frac{1}{8}$	$6\frac{1}{2}$	$7\frac{1}{8}$	$6\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{5}{8}$	$7\frac{1}{4}$	7	7	$4\frac{5}{8}$	$4\frac{1}{2}$	$4\frac{5}{8}$	30	5	66	76	
		4		12'30	$6\frac{3}{4}$	$5\frac{1}{8}$	$6\frac{1}{8}$	$6\frac{1}{2}$	$7\frac{1}{8}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{5}{8}$	7	$6\frac{3}{4}$	$7\frac{1}{8}$	$4\frac{5}{8}$	$4\frac{1}{2}$	$4\frac{5}{8}$	30	$4\frac{7}{8}$	66	79	
		5		12'40	$6\frac{3}{4}$	$5\frac{5}{8}$	6	$6\frac{1}{2}$	$7\frac{1}{4}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{3}{4}$	$6\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{1}{2}$	7	$6\frac{3}{4}$	$6\frac{7}{8}$	$4\frac{5}{8}$	$4\frac{1}{2}$	$4\frac{5}{8}$	30	$4\frac{3}{4}$	65	78	
		6		12'50	$6\frac{7}{8}$	$5\frac{1}{4}$	6	$6\frac{1}{2}$	$7\frac{1}{8}$	$6\frac{5}{8}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{5}{8}$	$6\frac{5}{8}$	$6\frac{7}{8}$	$6\frac{3}{4}$	$7\frac{1}{8}$	$4\frac{5}{8}$	$4\frac{1}{2}$	$4\frac{5}{8}$	30	$4\frac{3}{4}$	65	78	
		7		1'00	$6\frac{5}{8}$	$5\frac{3}{4}$	6	$6\frac{5}{8}$	7	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{5}{8}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{5}{8}$	7	$6\frac{1}{2}$	$4\frac{9}{16}$	$4\frac{5}{8}$	$4\frac{5}{8}$	30	5	66	$79\frac{1}{2}$	
	Averages		.....		— 6.17 —			— 6.64 —												— 4.6 —			.....		65.6	78.3	.....
	B	8	Nov. 30.	2'00	$3\frac{1}{2}$	$3\frac{1}{2}$	$2\frac{7}{8}$	3	$3\frac{5}{8}$	$2\frac{7}{8}$	3	$3\frac{1}{16}$	$3\frac{1}{8}$	$2\frac{15}{16}$	3	3	$3\frac{1}{16}$	$3\frac{1}{8}$	$3\frac{1}{16}$	$2\frac{1}{8}$	$2\frac{1}{8}$	$2\frac{3}{16}$	$27\frac{1}{2}$	$2\frac{5}{8}$	$63\frac{1}{2}$	$75\frac{1}{2}$	29.86
		9		2'10	$3\frac{1}{2}$	$3\frac{1}{2}$	$2\frac{15}{16}$	$2\frac{7}{8}$	$3\frac{1}{4}$	$2\frac{7}{8}$	$3\frac{1}{16}$	$3\frac{1}{8}$	$3\frac{1}{16}$	$3\frac{1}{16}$	3	3	$3\frac{1}{4}$	$3\frac{5}{16}$	$3\frac{1}{8}$	$3\frac{1}{4}$	$2\frac{1}{8}$	$2\frac{1}{8}$	$2\frac{1}{8}$	$27\frac{1}{2}$	$2\frac{5}{8}$	$61\frac{1}{2}$	75	
		10		2'20	$3\frac{3}{16}$	$3\frac{3}{16}$	$2\frac{15}{16}$	$3\frac{1}{4}$	$3\frac{1}{4}$	$2\frac{15}{16}$	$3\frac{1}{4}$	$3\frac{1}{8}$	3	3	$3\frac{1}{16}$	$3\frac{1}{16}$	$3\frac{1}{4}$	$3\frac{1}{4}$	$3\frac{1}{4}$	$2\frac{1}{8}$	$2\frac{1}{8}$	$2\frac{1}{8}$	27	$2\frac{7}{16}$	62	75	
		11		2'30	$3\frac{3}{16}$	$3\frac{3}{16}$	$2\frac{15}{16}$	$2\frac{7}{8}$	$3\frac{1}{4}$	$2\frac{7}{8}$	3	$3\frac{1}{16}$	3	$2\frac{7}{8}$	3	3	$3\frac{1}{4}$	$3\frac{1}{8}$	$3\frac{1}{4}$	$2\frac{1}{16}$	$2\frac{1}{16}$	$2\frac{1}{16}$	$25\frac{1}{2}$	$2\frac{5}{16}$	59	71	
	Averages		.....		— 3.063 —			— 3.075 —												— 2.125 —			.....		61.5	74.1	.....

*Center.

TABLE II.

SIROCCO BLOWER TESTS.

Average Readings of Numbered Tests in Each Group.

	Condition.	Test.	Number of test.	Time of test, November 30, 1904.	Steam pressure in pounds at governor valve.		Temp. of steam, deg. C.	Vacuum, ins. mercury.	Revolutions per minute.	Number nozzles open.	Test noz. open in minutes.	Net steam condensed in pounds.	Total steam used in pounds per hour.	Air horsepower, A.H.P.	Brake horsepower, B.H.P.	Efficiency, per cent. A.H.P. ÷ B.H.P.	Steam in lbs. per hour, per A.H.P.	Steam in lbs. per hour, per B.H.P.	Air discharged, in cubic feet, per minute.	Load on brake lever, lbs.
				Hour.	*Above.*	*Below.*														
Blower.	Con.*	A	1, 2	12·00–12·20	194.5	164	196.3	25⅛	1507.5	7	2	7	...	...	...	...	...	...	...	...
			3, 5	12·20–12·50	193.3	164	197.6	25⅛	1501.4	7	2	7	...	...	...	...	...	...	...	...
			6, 7	12·50– 1·10	193.5	163.5	197	25⅛	1500	7	2	6.6	...	...	...	...	...	...	...	...
		Aver.	...	...	193.9	163.7	197	25.84	1502.8	7	2	6.866	1,441.86	34.45	63.54	54.2	42.09	...	33,170	...
	Con.*	B	8, 9	2·00– 2·20	170	167.75	188	26 $\frac{6}{16}$	1041.5	3	2	7.1	...	...	...	...	...	...	...	...
			10, 11	2·20– 2·40	166	164	187.5	26 $\frac{7}{16}$	1022.5	3	2	6.9	...	...	...	...	...	...	...	...
		Aver.	...	...	168	165.8	187.75	26⅛	1031.5	3	2	7	630	10.81	22.98	47.05	58.26	...	22,230	...
Turbine.	Con	C	12–15	3·55– 4·20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Aver.		...	...	170	163.5	187.2	26.38	1048.7	3	2	6.6	594	...	21.67	...	...	27.41	...	31
	Con	D	16–19	4·45– 5·15	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...
	Aver.		...	...	195	160.25	195.5	25.48	1532.2	7	2	7	1,470	...	64.77	...	...	22.69	...	63.43
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

*Condensing.

NOTE.—In tests, groups A and D correspond, and B and C correspond.

Test "C", turbine performance at about 1,500 R.P.M., blower disconnected, condensing.

Test "D", same at about 1,000 R.P.M., condensing.

TABLE III.

CALIBRATION OF GAUGES USED DURING TEST OF BLOWER.

Standard gauge.	Gauge below governor valve.	Gauge above governor valve.
150	150	155
155	155	160
160	160	165
165	165	170
170	170	175
175	175.5	180
180	180.5	185
185	186.5	190
190	191	195
195	...	200
200	...	205

Tested December 1, 1904.

CALCULATION OF BLOWER RESULTS.

26. *Air Delivery.*—In order to obtain accurate figures for the density of the air and its dependent velocity head, the usual observations of temperature, atmospheric pressure and also moisture were made, the results being recorded in Table I. The amount of moisture contained in the air influences final results but slightly, except during extraordinay atmospheric conditions, but is noted so as to obtain more absolute comparison with other tests made on blowers.

27. The following formulae will give the density with relation to foregoing items:

$$W = \frac{0.0807\ (p - 0.379\ h \times e)}{(1 + \propto t)\ 29.921},$$

where

0.0807 = the weight of 1 cubic foot of dry air at 32 degrees Fahrenheit, and at a normal atmospheric pressure of 29.921 inches.

p = atmospheric pressure;
h = relative humidity;
e = vapor pressure;

$1 + \alpha t$ = the volumetric ratio of dry air at temperature 32 degrees Fahrenheit and at $(32 + t)$ degrees Fahrenheit;

t = temperature of dry air above 32 degrees;

.379 = the percentage of vapor contained in one pound of saturated air at 32 degrees.

Then for average results in Test "A", the following is obtained:

$$h = .55;\ e = 1.015;\ t = 45.5 \text{ degrees F.};\ p = 29.86;$$
$$1 + \alpha t = 1.093;$$
$$W = \frac{0.0807\ (29.86 - 1.015 \times .55 \times .379)}{1.093 \times 29.921} = .07298.$$

The velocity of discharge is $V = \sqrt{2g\,H}$ feet per second, H being the height of an air column which balances the mean height of water columns recorded in Pitot tube readings, and thus:

$$H = \frac{62.24 \times 6.64}{12 \times 0.07298} = 471.7 \text{ feet, and}$$
$$V = \sqrt{2 \times 32.16 \times 471.7} = 174.2 \text{ feet per second.}$$

The amount of air discharged per second is $Q = C \times A \times V$, in which equation

A = area of nozzle in square feet = 3.15;
C = a constant allowing for the contraction of air current in the nozzle. This constant, owing to size and shape of nozzle (See Fig. 5), may, without an appreciable error, be made equal to 1, and
$Q = 3.15 \times 174.2 = 549.5$ cubic feet per second
$= 60 \times 549.5 = 33{,}170$ cubic feet per minute.

Brake horsepower: For Test "D", corresponding to Test "A", of blower—Length of lever, 3 feet 6 inches; load on lever, 63.43 pounds; number revolutions of pulley = 1,532.2.

$$H.P. = \frac{6.28 \times 3.5 \times 1{,}532.2 \times 63.43}{33{,}000} = 64.77, \text{ Test "D", normal.}$$

$$= 21.67, \text{ Test "C", reduced.}$$

Steam per brake horsepower: Total steam used per hour divided by brake horsepower $= \frac{1{,}470}{64.77} = 22.69$ pounds per hour.

It will be noticed that the turbine ran about 30 revolutions faster during Test "D" (brake) than during Test "A" (blower), and the brake horsepower of the blower, therefore, deduced from total steam consumed by blower and steam per brake horsepower will be:

$\frac{1{,}441.86}{22.69} = 63.54$ and $\frac{630}{27.41} = 22.98$ respectively for "*A*" and "*B*".

Air horsepower: The energy in foot pounds developed by the air discharged per second from the nozzle moving at a velocity V must equal the work expended upon it, thus:

$$A.H.P. \times 550 = 0.07298 \times 549.5 \times \frac{174.2^2}{2g} \text{ and}$$

$A.H.P. = 34.45$ for conditions in Test "A" and

$= 10.81$ for conditions in Test "B".

Efficiency of blower: Dividing air horsepower with brake horsepower will give the efficiency;

$$\text{Then, } E = \frac{34.45}{63.54} = 54.2 \text{ per cent. at normal output,}$$

$$\text{Then, } E = \frac{10.81}{22.98} = 47.05 \text{ per cent. at reduced output.}$$

Steam per air horsepower: For normal conditions, 42.09 pounds per hour. For reduced conditions, 58.28 pounds per hour.

A synopsis of data with reference to these tests will be found on Table II.

29. In comparison with fans of the Sturtevant type, installed on the U. S. S. *Minneapolis*, and driven by a set of two-cylinder reciprocating, simple engines, the following is submitted. The figures are derived from steam-consumption tests made by W.

W. White, U. S. N. (See Volume X, JOURNAL OF AMERICAN SOCIETY OF NAVAL ENGINEERS.)

ENGINE BLOWER. *Sturtevant, Test.*		TURBINE BLOWER. *Sirocco, Test.*	
Air pressure, inches	.7	Air pressure, inches	2.1
Steam pressure, pounds	120	Steam pressure, pounds	164
Vacuum, inches	15¼	Vacuum, inches	26.34
I.H.P.	16.3	I.H.P.	...
B.H.P. (based on combined mechanical efficiency of engine and blower equal to .8)	13.04	B.H.P.	22.98
A.H.P. (calculated)	7.75	A.H.P. (as tested)	10.81
Efficiency of blower, per cent.	59.45	Efficiency of blower	47.05
Steam per A.H.P., pounds	162	Steam per A.H.P.	58.26
B.H.P.	96.82	B.H.P.	27.41

NOTE.—Figures above refer to two-thirds capacity of normal for turbine blower and thus, far below those given for normal output.

30. The air horsepower of engine blower is figured by the usual formula, (no tests of air discharge having been performed when tests for steam consumption were carried out); while the figures given for the turbine blower are taken and put down from the tests. The result of the comparison shows however, that the steam used per Brake horsepower in the two different systems is much in favor of the turbine, and would be under non-condensing conditions with the turbine, even though it be granted that the steam consumption then would be twice as great, which, as will be seen later in the pump tests, is not quite the condition.

31. The efficiency of the Sirocco fan is apparently not as good as the ordinary type; but as this fan adapts itself better for a turbine drive with its high number of revolutions, it seems justifiable to recommend its adoption for certain purposes.

32. Furthermore, values of efficiency probably will be somewhat modified by variations in conditions, and final conclusions should not be drawn from the few tests made; but additional tests should be performed with Sirocco fans when run with

turbines, to enable the determination of conditions that will give maximum efficiency as well as the limits within which said blowers may be used to advantage.

33. Attention is drawn to the following points:

1. In comparison with blowers shown in official plans of the new scout cruisers, the "Sirocco" turbine blower takes up less room, as per following table:

Sturtevant-Engine.		*Sirocco-Turbine.*	
Length, inches	96	Length, inches	96
Breadth, inches	70	Breadth, inches	42
Height, inches	84	Height, inches	54
R.P.M	418	R.P.M	1,500
Diameter of fan, inches	66	Diameter of fan, inches	20
Width of fan (tip), inches	20	Width of fan (tip), inches	24
Weight, pounds	2,650	Weight, pounds	4,360

The greater weight of the turbine blower is readily accounted for by the extremely heavy bedplate upon which it was mounted. The bedplate, however, may be considerably reduced in weight when designed to conform to installations on board ship.

2. A turbine-driven blower works steadier and with less noise; it does not require any special care in adjustments when in operation, and is probably less liable to break down at speeds necessary to give the high air pressures required in special cases.

3. It is more economical, both in steam and in oil required.

TEST OF CENTRIFUGAL PUMP.

34. The pump in question was built for Messrs. Jones & Laughlin, of Pittsburg, Pa., and was intended for service in connection with the local fire system within their works. It was mounted, together with the turbine, in a convenient position to draw from and discharge into the storage tanks built under the floor of the testing room. The discharge pipe was furnished with a converging nozzle of such shape that the loss due to contraction at the outlet was considered negligibly small. (See Fig. 8.)

35. The velocity head was recorded in accordance with readings obtained with a Pitot tube in connection with a vertical glass gauge fastened to the wall and graduated in inches for a height of about 28 feet. The output of the pump was determined by this method alone, weir tests being impracticable, owing to the limited capacity of the tanks.

36. The rated capacity of the pump was about 10,000 gallons per minute with a thirty-foot total lift, but, owing to the limited capacity of the tanks and to difficulties then arising when handling such large amounts of water, it was arranged to discharge one-half this quantity, but against a sixty-foot head, the average water horsepower of the latter being equivalent to the first, other conditions being similar.

37. Four tests of the pump and four tests with the turbine disconnected from the pump were performed. In each series two tests comprised condensing conditions, while the other were non-condensing. Tabulated average results of Pitot tube readings relating to suction and discharge heads, together with other results, will be found in Table IV.

Test "E" constitutes pump performance at about 1,200 R. P.M., condensing (normal).

Test "F," same at about 975 R.P.M., condensing.

Test "G," same at about 975 R.P.M., non-condensing.

Test "H," same at about 1,200 R.P.M., non-condensing.

Test "K" constitutes turbine performance at about 1,200 R.P.M., non-condensing.

Test "L," same at about 975 R.P.M., non-condensing.

Test "M," same at about 975 R.P.M., condensing.

Test "N," same at about 1,200 R.P.M., condensing.

At the finish of each complete series of tests the gauges were removed and calibrations carefully made. The results will be found in Table V.

While performing the brake tests the pump was disconnected from the turbine and a Prony brake connected to each gear shaft. Adjustments were made to bring about uniformity in the conditions for corresponding tests.

TABLE IV.

CENTRIFUGAL PUMP TESTS.

Average Reading of Numbered Tests in Each Group.

Condition.	Test.	Number of test.	Time of test, year 1904.		Steam pressure in pounds at governor valve.		Temp. of steam, degrees C.	Vacuum, inches mercury.	Revolutions per minute.	Number of nozzles open.	*Test nozzle open, minutes.	*Net steam condensed, lbs.	Total steam, pounds per hour.	Water horsepower, W.H.P.	Brake horsepower, B.H.P.	Efficiency, W.H.P. ÷ B.H.P.	Pounds steam per hour per W.H.P.	Pounds steam per hour per B.H.P.	Water discharge, gallons per minute.	Vacuum in suction pipe at pump, inches mercury.	Pressure in discharge pipe at pump, lbs. per square inch.	Total lift in feet.	Pressure in Pitot tube.	Load in pounds on brake lever.
			Day		Above.	Below																		
Centrifugal pump. Condensing.	E	20, 21, 22, 23	December 1.	11·25 to 11·55	195	172	192·7	26.14	1,315	7	2	9	1,890	76.7	...	72.1	24 64	...	5,110	7.562	21.6	59·4	18–10	...
	F	24, 25, 26, 27		12·35 to 1 05	185	184	187	26.98	974	4	2	9·3	1,116	42	...	62 3	26.57	...	...	5.187	24·35	62.98	8–11½	...
	G	28, 29 30		2 10 to 2·30	160	158 4	182	0	996	3	1·5	20 2	2,430	43·3	...	61.7	56.12	...	2,660	5.075	25	64 46	9– 4	...
	H	31, 32, 33		2 55 to 3·15	192.6	180 5	191.6	0	1,213	4	1	14 5	3,480	77·1	...	71.6	45·15	...	5,120	7 542	21.73	59.66	18–10¾	...
Turbine. Non-condensing.	K	34, 35, 36	December 2.	10 15 to 10 35	194	178.6	191·1	0	1,212	4	1	14 3	3,435	...	108.2	...	31·7	...	...	...	...	...	...	104.53
	L	37, 38, 39		11·05 to 11·25	165	168.5	188	0	968	3	1·5	20	2,400	...	70.1	...	34·2	...	...	...	...	...	...	84·5
	M	40, 41, 42		12·45 to 12·55	186	185	190	27.125	967·5	4	2	10	1,200	...	66 3	...	18 1	...	...	...	...	...	...	80
Condensing.	N	43, 44, 45		1·00 to 1·10	194·5	169.75	190	26 187	1,209	7	2	8 6	1,805	...	106.3	...	16 95	...	...	...	...	...	...	102 55
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

NOTE.—Tests E and N correspond, F and M correspond, G and L correspond, and H and K correspond. Size of steam nozzles, 4.7 mm. condensing; 8.7 mm. non-condensing. Size of water nozzles, No. 32, or 7 947 inches for E and H; No. 24, or 6.882 inches for F and G. Temperature of air, 20 degrees C.; of water, 15 degrees C.

*Only one observation in each group.

TABLE V.

CALIBRATION OF GAUGES USED DURING TEST OF PUMP.

Standard gauge.	Gauge No. below governor valve.	Gauge No. above governor valve.	Gauge at delivery of pump.
15	...	...	14
20	...	...	19.1
25	...	...	24.2
30	...	...	29.5
165	164.5	170	...
170	170	175	...
175	175	180	...
180	180.5	185	...
185	186	190	...
190	191	195	...
195	196.5	200	...
200	201.5	204	...
...	...	209	...

Tested December 2, 1904.

CALCULATION OF PUMP RESULTS.

38. *Water discharge:* Weir tests, as already mentioned, not being practicable, it was necessary to make calculations from data obtained on the "Pitot tube basis." Experiments have shown (some of recent date by Professors Denton and Kent,) that the quantity discharged may accurately be ascertained from the formula:

$$Q = C \times \text{area of nozzle} \times \sqrt{2gH}$$

with a value of C varying between .953 and .977 and may, with reliability, be assumed to equal at least .95. For average readings in Test "E", $H = 18$ feet 10 inches, the height of water column in Pitot tube, and

$$Q = .95 \times \frac{49.54}{144} \sqrt{64.32 \times 18.833} = 11.39 \text{ cubic feet per second}$$
$$= 5{,}110 \text{ gallons per minute.}$$

39. *Brake horsepower:* From data corresponding to conditions in Test "E".

Length of lever, feet and inches	4- 6
Load on lever, pounds	102.55
Number revolutions of pulley	1,212

$$B.H.P. = \frac{6.28 \times 4.5 \times 1{,}212 \times 104.55}{33{,}000} = 106.3.$$

40. *Steam per brake horsepower:* For Test "E"

$$= \frac{1{,}805}{106.3} = 16.95 \text{ pounds per hour.}$$

40. *Water horsepower:* From Table IV, total lift, obtained by adding suction and discharge heads, equals 59.4 feet.

$$W.H.P. = \frac{5{,}110 \times 59.4 \times 8.376}{33{,}000} = 76.7.$$

41. *Efficiency of pump:* Water horsepower divided by brake horsepower gives efficiency, and thus:

$$E = \frac{76.7}{106.3} = 72.1 \text{ per cent. at normal output.}$$

42. *Steam per water horsepower:* For Test "E".

$$\frac{\text{Total steam}}{W.H.P.} = \frac{1{,}890}{76.7} = 24.64 \text{ pounds per hour.}$$

A synopsis of results made up from average readings will be found on table IV.

43. The efficiency, although good, is not as high as has been obtained at other times with this type of pump. In the results obtained with centrifugal pumps built for the U. S. A. C. *West Virginia*, and tested at the works of the Newport News Shipbuilding Company, of Newport News, Va., the following comparative efficiency is submitted:

Engine pump, 61.6 per cent.
Turbine pump, 72.1 per cent.

The efficiency of the engine pump was figured on the basis of brake horsepower, which was obtained by multiplying the I.H.P. with an assumed combined mechanical efficiency of .8 for engine and pump.

44. The reason of a higher efficiency with turbine pumps will no doubt be found due to the considerably lessened frictional resistances in the small impellers used in those pumps. Frictional resistances of revolving discs, as have been found

experimentally, increase in the fifth power of the radius, while only in the third power of the revolutions.

45. With reference to steam consumption of the turbine pump when placed in comparison with an engine-driven pump, the following data are submitted. These data are taken from the same source as those previously referred to in the Sirocco blower tests.

Engine pump.		*Turbine pump.*	
Type of engine :		Type of turbine :	
Simple, two-cylinder, slide valve.		De Laval condensing.	
Steam pressure, pounds	154	Steam pressure, pounds	185
Vacuum, inches	13	Vacuum, inches	27.1
I.H.P.	18.87	I.H.P.	...
B.H.P. (.8 I.H.P.)	15.1	B.H.P.	66.3
Steam per B.H.P., pounds	36.5	Steam per B.H.P., pounds	18.1
R.P.M	172	R.P.M	968

NOTE.—Above conditions given for turbine pump correspond to one-half the normal capacity.

46. The following comparative figures give space and weight of the ordinary type of centrifugal pumps as shown in the official plans of the new scout cruisers and the turbine-driven pump described in tests. Capacity is the same in both cases, or 10,000 gallons per minute.

Engine pump.		*Turbine pump.*	
Length, feet and inches	,8-6	Length, feet	13
Width, feet and inches	4-6	Width, feet	5
Height, feet and inches	6-6	Height, feet and inches	3-3
Weight, pounds	9,520	Weight, pounds	12,900

47. The following may be inferred from the foregoing tests and figures:

1. For small heads, such as is common on board ship for bilge or circulating purposes, the ordinary single-stage pump, although more wasteful of steam, seems better adapted than the series or multiple-stage pump, the former weighing less and taking up less room. For fire service or distiller circulating purposes the turbine pump may be used with decided advantage.

2. The turbine pump excels in efficiency the ordinary centrifugal pump, as shown by the foregoing tests.

3. In its use of steam the turbine-driven pump is superior to the ordinary type, depending principally on the greater economy of the turbine, and in a lesser degree on the higher pump efficiency.

CONCLUSIONS.

a. Steam turbines inherently possess advantages over the reciprocating engine for driving centrifugal machines, and will, in our opinion, in many instances, replace the engine in driving both centrifugal pumps and blowers.

b. The De Laval steam turbine, being specially adapted for powers below 300 H.P., and, unlike the engine, possesses an acceptable degree of efficiency when built in small units, will be superior, especially when placed in positions where temperature and cramped facilities render the engine undesirable on account of its need of constant attention.

c. Whether reduction in weight or saving of space actually will be brought about by the adoption of these motors cannot definitely be determined before comparative trials have been made and a broader field opened to the turbine makers, enabling them to specialize their machines to suit particular naval requirements.

d. It is recommended that an installation of turbine-driven centrifugal pumps and forced-draft blowers be made for at least one of the scout cruisers to be contracted for by the Navy Department in the near future.

Very respectfully,

A. B. CANAGA,
Commander, U. S. N.
H. C. DINGER,
Lieutenant, U. S. N.
ERNEST N. JANSON,
Of the Bureau of Steam Engineering,
Navy Department.

THE CHIEF OF THE
BUREAU OF STEAM ENGINEERING,
Navy Department.

THE U. S. S. *CHATTANOOGA.*

GENERAL DESCRIPTION—STANDARDIZATION AND OFFICIAL TRIALS.

By Lieutenant Commander W. W. White, U. S. Navy, Member.

The sheathed protected cruiser *Chattanooga* (Cruiser No. 16) is one of six (designated as the *Denver* class) contracted for by Lewis Nixon (Crescent Shipyard) of Elizabethport, N. J., on December 14, 1899, to be finished in thirty months. In event of delay in completion a penalty of $300 was to be exacted for each day (except Sundays) for the first month, after the expiration of the contract time, $400 for each day of the second month, and thereafter at the rate of $600 per day. * Machinery weights were limited to 427 tons, with a penalty of $500 per ton for excess weight, and an additional fine of $10,000 in case the total weight as specified was exceeded by 5 per cent.

SCHEDULE OF WEIGHTS (DESIGNED).

Hull and fittings, not including protective-deck armor, tons	1,706
Protective-deck armor, 2-inch, tons	62
Cellulose, tons	24
Armament and ammunition, tons	213
Equipment, stores and outfit, tons	287
Propelling machinery, with water, tons	441
Coal, tons	467
Total	3,200

The speed to be developed and maintained successfully for four consecutive hours was to be not less than an average of 16½ knots, the air pressure in the firerooms being limited to 1 inch of water. In case the speed fell below 16½ knots on trial, but above 15½ knots, the vessel was to be conditionally accepted, subject to a deduction from the contract price of the

*Includes engines, boilers and appurtenances, all fixtures in engine and firerooms, smoke pipes, distilling apparatus, stores, spare parts, heating apparatus, tools in workshop, water in boilers, condensers, pumps, pipes and stern tubes (but not including reserve feed water, capstan, windlass, steering gear or winches).

vessel on account of such failure at the rate of $25,000 a quarter of a knot for speed between 16½ and 16, and $50,000 a quarter knot between 16 and 15½ knots. If the vessel failed to exhibit an average speed of 15½ knots, her acceptance, at a reduced price to be agreed upon, was optional.

The keel was laid on the 29th of March, 1900, and after many delays the ship was launched on March 7, 1903, her contract date of completion having been June 14, 1902. When the shipbuilding trust, of which the Crescent Shipyard was a member, collapsed, the vessel was taken possession of by the Government, under the twelfth clause of the contract, which provided that in case of failure or omission of the contractor, at any stage of the work, to make satisfactory progress towards completion of the vessel the contract was to be forfeited. The vessel was removed to the navy yard, New York, about the middle of October, 1903, to be completed by the Government.

A Board of five naval officers was appointed to make a complete inventory of all work done or commenced upon the vessel, and all material furnished or on hand for the purposes of construction. This Board, under date of October 7, 1903, reported in part as follows:

"The original contract price of the *Chattanooga* was one million thirty-nine thousand nine hundred sixty-six dollars ($1,039,966). This is apportioned between hull (including equipment and ordnance) and machinery as follows:

Hull, ...	$639,966.00
Machinery, ...	400,000.00
	1,039,966.00

"Changes in the hull have increased the portion allotted to it by the sum of $3,806.52, making the revised hull allotment $643,772.52.

"Changes in the machinery have decreased the portion allotted to it by the sum of $834, making the revised machinery allotment $399,166.

"The revised hull and machinery allotments give a total, for basis of valuation, of $1,042,938.52.

Amount earned on hull, including extras, . .	$449,529.30
Amount earned on machinery, including extras,	320,382.00
Total amount earned, ...	769,911.30
Cash paid on hull, ...	422,891.64
Cash paid for extras, ...	1,764.00
Cash paid on machinery, ...	325,883.88
Total cash paid contractor, . . .	750,539.52
Total amount earned (estimated), . . .	769,911.30
Total amount paid, ...	750,539.52
Balance due contractor, ...	$19,371.78

"The amount of seven hundred sixty-nine thousand nine hundred eleven dollars and thirty cents ($769,911.30) the Board declares to be a fair market value of the work and material belonging to the *Chattanooga*, including a reasonable margin of profit upon so much of the work as has been satisfactorily performed at the time of the forfeiture of the contract, the cost price plus extras being taken as the fair market value of the completed vessel."

It will be seen from the above that at the time of removal of the vessel to the New York Navy Yard there remained available, in accordance with the contract price, the sum of $273,027.22. Of this amount $194,243.22 was for finishing the hull and $78,784 the machinery.

As complete descriptions of this class of ships have appeared at various times in the JOURNAL, it will be only necessary to repeat here the principal dimensions. For more extended data, the reader is referred to Vol. XV, page 1110 (Trial of U. S. S. *Cleveland*), Vol. XVI, page 1 (U. S. S. *Tacoma*), page 67 (U. S. S. *Denver*), and page 227 (U. S. S. *Des Moines*).

HULL.

The hull is constructed of mild steel, the outer plating being composed generally of 15-pound plating. There are one hundred transverse frames, spaced 3 feet apart, and formed of

Z-bars (frames 18 to 36), 6 inches by $3\frac{1}{2}$ inches by $3\frac{1}{2}$ inches by $15\frac{1}{2}$ pounds, except forward and aft (frames 1 to 17 and 87 to 100), which are 4 inches by $3\frac{1}{2}$ inches by 9.1 pounds angle bars. The outside plating is sheathed with Georgia pine, 4 inches thick, extending to about 42 inches above the water-line amidships, shearing up forward to 69 inches, and aft to 51 inches.

Length L. W., feet	292
over all, feet and inches	308-9
Beam molded, feet and inches	43-3½
extreme, feet	44
Mean draught (with 467 tons coal and two-thirds stores), feet and inches	15-9
Corresponding displacement, tons	3,200
Area of midship section, square feet	615.2
load-water plane, square feet	9,370
Tons per inch of immersion	22.3

ARMAMENT.

Main battery	10 5-inch R. F. guns, 8 6-pdrs.
Secondary battery	2 1-pdrs., 4 Colt's automatic.
Mean height of axis of 5-inch guns, main deck, above load-water line, feet and inches	21-5
gun deck, above load water line, feet and inches	12-4

MACHINERY.

There are two triple-expansion, four-cylinder engines, of the vertical, inverted type, placed abreast of each other in separate watertight compartments, and designed to develop a total of 4,500 I.H.P. at about 172 revolutions. The engines are right-and-left, turn inboard, and have the following sequence of cylinders, beginning forward: Forward low pressure, high pressure, intermediate pressure and after low pressure.

Steam is supplied by six water-tube boilers of the Babcock & Wilcox *Alert* type.

ENGINES.

Number of engines	2
cylinders, each engine	4
Stroke (common), inches	30
Diameter H.P. cylinder, inches	18
I.P. cylinders, inches	29

Diameter L.P. (2) cylinders, inches	35½
Volumetric cylinder clearances (mean of top and bottom) cubic ins. :	
H.P. (20.66 per cent.)	1,577
I.P. (15.87 per cent.)	3,143
L.P.'s (11.97 per cent.)	3,553
Valves, H.P. (one piston for each cylinder), diameter, inches	11
I.P. (two for each cylinder), diameter, inches	11
L.P. (one double-ported slide for each cylinder), inches, length, 25½; width, 39½; port, length	37

DETAILS OF VALVE SETTINGS.

	H.P.		I.P.		L.P.	
Travel of valve, inches	4		4		4	
Side of valve on which steam is taken,	Inside.		Outside.		Outside.	
	Top.	*Bottom.*	*Top.*	*Bottom.*	*Top.*	*Bottom.*
Width of port, inches	1½	1½	1½	1½	1½×37	1½×37
Steam lap, inch	1 5/32	1 5/32	1 5/32	1 5/32	1 5/32	1 5/32
Exhaust lap, inch	−7/32	−1/32	−9/16	−1/16	+1/16	+3/32
Angular advance, degrees	35		35		40	
Steam lead, angular, degrees	7	8	6.25	7.75	13	14.50
linear, inch	7/32	9/32	6/32	9/32	1 1/32	7/16
Cut-off, in inches, maximum	23½	20½	22 1/16	20⅝	22⅜	20
decimal of stroke	.771	.695	.764	.688	.745	.665
Exhaust release, in inches	27	26½	26⅛	26⅛	27¼	26½
Compression, in inches	2 3/16	2	1⅞	1 13/16	4 3/16	3⅜
decimal of stroke	.072	.067	.060	.065	.138	.123
Steam opening, inches	1 1/16	1 3/32	1 1/16	1 3/32	1 3/32	1¼
Exhaust opening	Full port.		Full port.		Full port.	

PROPELLERS.

Number of blades	3
Diameter, feet and inches	10–6
Pitch, feet and inches (as set on trial)	11 8 5/16
Helicoidal area, each screw, square feet	33.7
Projected area, each screw, square feet	28.7

BOILERS.

Number	6
Furnaces in each	Full width of boiler, with three doors.
Width of furnaces (internal), feet and inches	7– 7
Length of grate, feet and inches	6– 6
Heating surface (total square feet)	13,200
Grate surface (total square feet)	300
Working pressure (designed), pounds per square inch	275

MACHINERY WEIGHTS IN DETAIL.

Actual weights of the various parts of the finished machinery, as built and installed, are as follows :

Group.		Tons.
I.	Main engine cylinders, receiver pipes, etc	25.486
II.	Shafting	19.660
III.	Main engine framing and bearings	25.698
IV.	Main engine reciprocating parts	7.403
V.	Main engine valve gear	6.845
VI.	Main condensers	11.583
VII.	Main air and circulating pumps and engines	5.584
VIII.	Propellers	5.692
IX.	Boilers	95.395
X.	Boiler fittings	38.050
XI.	Smoke pipes and uptakes	26.796
XII.	Steam and exhaust pipes and valves	15.390
XIII.	Suction and discharge pipes and valves	22.411
XIV.	Lagging and clothing	5.791
XV.	Flooring, gratings, etc	16.209
XVI.	Auxiliaries	20.748
XVII.	Fittings and gear	13.014
XVIII.	Water	36.718
XIX.	Stores, tools and spare parts	17.416
XIX*a*.	Government stores	19.709
XX.	Miscellaneous machinery, heating, distilling and refrigerating plants	24.483
XXI.	Other miscellaneous machinery, C. & R. and Equipment	89.572
XXII.	Connections under steam engineering to other miscellaneous machinery	3.267
	Total	443.639

COMPLEMENT.

Prior to the official trial, and as the *Chattanooga* neared completion, she was placed in commission at the navy yard, New York, on October 11, 1904. The trials were run, therefore, by her regular crew. Her complement of officers and men is—

Commissioned and warrant officers,	18
Deck force,	162
Artificer (deck) branch,	16
Engineer force,	83
Yeoman (special branch),	11
Messmen,	24
	314

PROGRESSIVE RUNS TO STANDARDIZE SCREWS.

For the purpose of establishing the official speed of the vessel, as required by the contract, the standardized screw method was employed. The measured-mile course in Narragansett Bay, off Newport, R. I., was used to fix data necessary to construct the curve of speed and revolutions, shown on Plate 1 (on a reduced scale), from which later the speed of the vessel in free route and in the open sea for four hours was determined.

Instructions for standardizing the screws over the measured mile course called for runs alternately with and against the tide, as follows: Three single runs, at 16½ knots, or the highest attainable speed; two single runs, at each of the speeds of 16, 14, 12, 10 and 8 knots, or a total of thirteen single runs.

Table I contains, in tabulated form, the important data of the actual runs made, and Table II other machinery data calculated or observed. Two Weaver recording instruments (for description see page 86, Vol. III, of the JOURNAL), independently connected and located in the pilot house, were used to determine the revolutions and time on the measured mile at each run. An observer was stationed on the forward bridge and another on the after bridge, each of whom, by means of a push button, recorded on the tape of the Weaver instruments the instant of passing the ranges at each end of the mile course. These observers were also provided with stop watches, and the time on the course for each run was thus, in addition, ascertained. Column 2 of Table I shows the mean of the four observations for time (two Weaver instruments and two deck observers), and columns 3 and 4 the average revolutions for each shaft, as determined from the Weaver tapes. In all cases there was a close agreement.

Previous to the vessel starting for standardization trials, the draught was taken and found to be:

Forward, feet and inches, ...	15–3
Aft, feet and inches, ...	16–1
Mean draught, feet and inches, . . .	15–7
Corresponding displacement, tons, . .	3,156

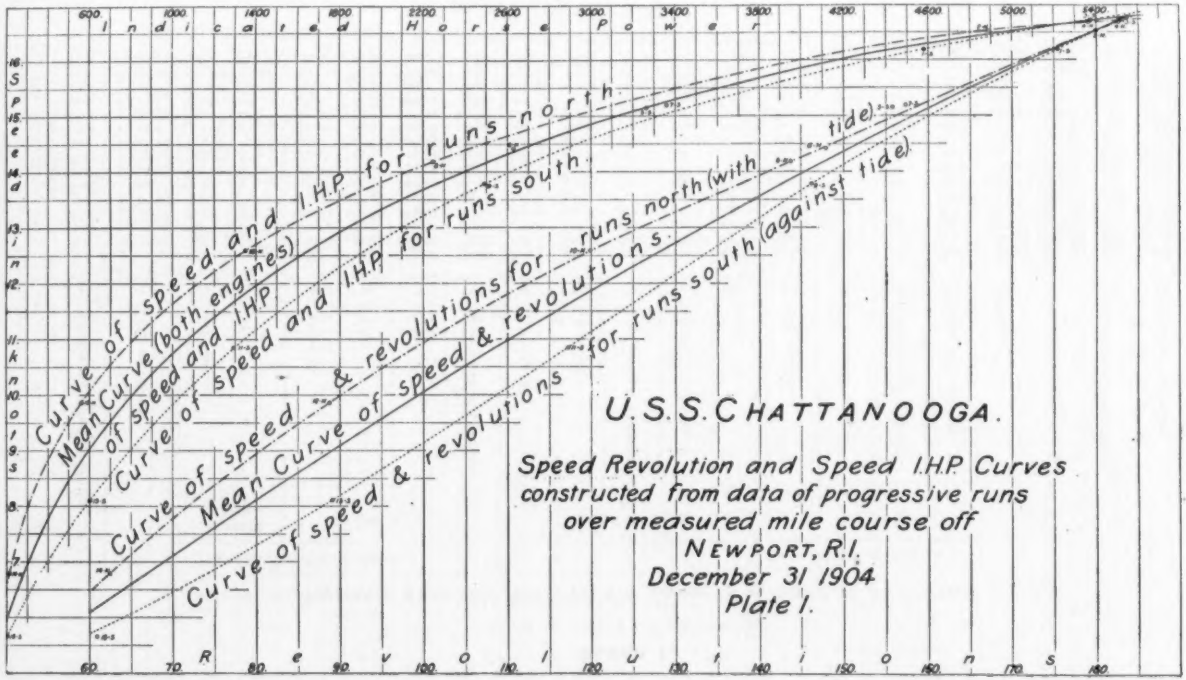

Indicated Horse Power
Revolutions per minute
Curve of speed and I.H.P. for runs north.
Mean Curve (both engines) of speed and I.H.P.
Curve of speed and I.H.P. for runs south.
Curve of speed & revolutions for runs north (with tide).
Mean Curve of speed & revolutions.
Curve of speed & revolutions for runs south (against tide).
U.S.S. CHATTANOOGA.
Speed Revolution and Speed I.H.P. Curves
constructed from data of progressive runs
over measured mile course off
NEWPORT, R.I.
December 31 1904
Plate I.

TABLE I.

U. S. S. *CHATTANOOGA.*

Data from Progressive Runs over Measured-Mile Course off Newport, R. I., December 31, 1904.

Number and direction of run.	Time on course.	Revolutions of main engines. To make 1 knot. Starboard.	Revolutions of main engines. To make 1 knot. Port.	Revolutions of main engines. Per minute. Starboard.	Revolutions of main engines. Per minute. Port.	Revolutions of main engines. Per minute. Mean.	Speed in knots per hour.	Indicated horsepower. Starboard engine. H.P. cylinder.	I.P. cylinder.	Forward L.P. cylinder.	After L.P. cylinder.	Total.	Indicated horsepower. Port engine. H.P. cylinder.	I.P. cylinder.	Forward L.P. cylinder.	After L.P. cylinder.	Total.	Total both main engines.	Auxiliaries in operation (estimated).	Total all machinery.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	m. sec.																			
1-s	3 42.35	655.1	645.35	176.78	174.14	175.46	16.19	700 5	802 3	418.9	401	2322.7	708.9	792	378	380.3	2259.2	4581.9	144	4725 9
2-n	3 37.17	650.1	649	179.11	178.81	178.96	16.53	698.4	876.6	401.3	386.3	2362 6	734.6	914.9	435.7	435.7	2520.9	4883.5	156	5039.5
3-s	3 35.18	655.3	655.95	182.72	182.9	182.81	16.73	730.9	896.6	460.2	440.1	2527.8	665.4	1116.7	530 5	530.5	2843.1	5370.9	164	5534.9
4-n	3 35.88	657.1	657.25	182.63	182.67	182.65	16.68	759.2	940.8	427.1	416.8	2543.9	796.9	1034.9	491 8	497.3	2820.9	5364.8	161	5525.8
5-s	3 57.63	617.45	616.2	155.9	155.59	155.75	15.15	538 6	576	202.2	242.8	1559 6	601.5	584 6	251.6	266.2	1703.9	3263.5	138	3401.5
6-n	4 09.6	615 6	615.15	147.98	147.88	147.93	14.42	456	460.9	165.1	192.6	1274.6	475	460.5	210.1	209	1354.6	2629.2	136	2765.2
7-s	3 57 05	619 65	623.4	156.84	157.79	157.32	15 19	515.5	562.2	227.5	288 2	1533 4	618.8	642.8	274.2	290.6	1826.4	3359.8	138	3497.8
8-n	4 13.93	607.65	608.95	143.58	143.9	143.74	14.18	382.4	412.6	156 1	156.1	1107.2	423.5	389.5	156.3	170	1139 3	2246.5	116	2382 5
9-s	4 21.25	634 85	638.55	145.8	146.65	146.23	13.78	408.4	443.3	160.7	170.9	1183.3	462 8	464	182.8	197.7	1307 3	2490.6	102	2592.6
10-n	4 45 95	571.05	571.55	119.82	119.93	119.88	12.59	226	214.8	113.7	109.3	663.8	241	203	121.5	121 5	687	1350.8	85	1435.8
11-s	5 31.95	649.25	648	117.35	117 13	117.24	10.85	214.8	188.6	104.7	101.4	609.5	233.2	208.4	119.2	122	682.8	1292.3	85	1377.3
12-n	6 05.03	539.25	540.45	88.64	88.83	88.74	9.86	101	82.2	45 1	43.7	272	110.5	87.8	50.4	41.4	290 1	562.1	74	636.1
13-s	7 24 03	601.75	656.95	89.42	88.77	89.1	8.11	112 9	101.1	49 5	45.4	308.9	111.1	87.8	47.9	45.4	292.2	601 1	74	675.1
14-n	8 50.13	532.75	531.6	60.3	60.17	60.24	6.79	43.9	29.5	14	17.9	105.3	43.4	33.5	15.1	16.2	108.2	213.5	55	268 5
15-s	10 36.33	638 9	635 6	60.24	59.93	60.09	5.66	40	28.3	14 6	15.2	98.1	47	29.6	15.1	13.9	105.6	203 7	55	258.7

TABLE II.

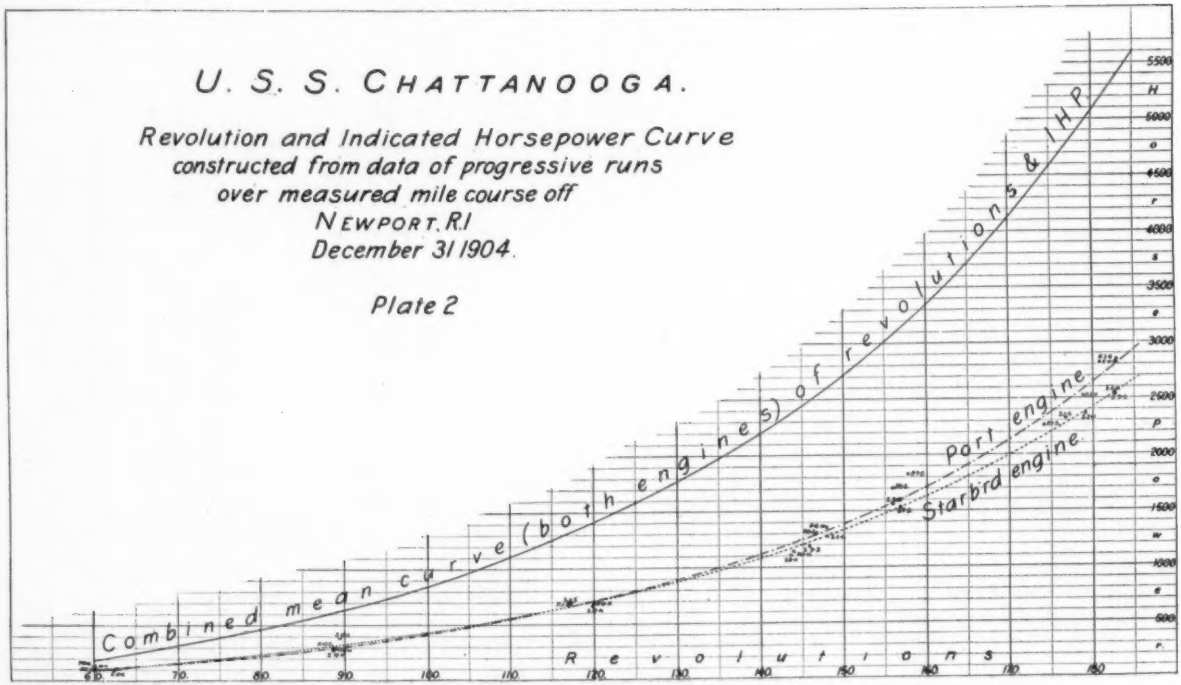
U. S. S. *CHATTANOOGA.*

TABLE II.

U. S. S. *CHATTANOOGA.*

Data from Progressive Runs over Measured-Mile Course off Newport, R. I., December 31, 1904.

Number of run.	Time at beginning of run (approximate).	Which engine.	Steam pressures.				Mean effective pressures.				Cut-off in cylinders from beginning.			Temperatures.					Revolutions or double strokes.							Air pressure, in ins. of water.
			In boilers above atmosphere.	At engine above atmosphere	H.P. steam chest, absolute.	In first receiver, absolute.	In second receiver, absolute.	H.P. cylinder.	I.P. cylinder.	Forward L.P. cylinder.	After L.P. cylinder.	Referred to low pressures.	Vacuum, inches.	H.P.	I.P.	Forward L.P.	After L.P.	Outside air.	Engine-room working platform.	Fireroom working level.	Injection.	Discharge.	Hotwell.	Feed.	Circulating pump.	Main feed pumps.	Auxiliary feed pumps.	Hotwell pump.	Water-service pump.	Bilge pump.	Aux. cond'r. pump.	Fireroom blowers.	
1-s	A. M. 9'08	St'b'd	235	230	93	30	106.1	45.9	15.93	15.25	44.16	25	.74	.73	.71	.71	36	88	70	33	72	60	240	26	...	60	90	...	420	I
1-n		Port	245	230	99	30	109	46	14.59	14.68	43.61	24.5	.74	.73	.71	.71		79		34	74	78	172	14	40	16	46	49		
2-n	9'37	St'b'd	257	240	97	30	104.4	49.5	15.06	14.5	44.34	25.7	.74	.73	.71	.71	37	88	68	33	72	65	240	27	...	...	60	90	480	I
		Port		250	105	30	110	51.75	15.38	16.38	47.39	24	.74	.73	.71	.71		80		34	79	82	175	16	36	16	46	48		
3-s	9'58	St'b'd	263	250	103	29.5	107.1	49.63	16.93	16 19	46.5	25	.74	.73	.71	.71	38	88	66	33	72	64	190	30	...	60	90	508	I
		Port		260	89	30	97.4	61.75	19.5	19.5	52.85	23.5	.74	.73	.71	.71		81		36	76	86	200	21	30	16	24	74		
4-n	10'25	St'b'd	261	255	102	30	111.3	52.1	15.72	15.34	46.61	25.5	.74	.73	.71	.71	38	88	66	33	78	68	190	28	...	60	60	48	502	I
		Port		255	105	30.5	116.8	57.3	18.1	18.3	51.9	25	.74	.73	.71	.71		82		34	78	75	186	24	18	24	76	48		
5-s	10'45	St'b'd	269	259	105	31.5	92.5	37.37	8.72	10.47	33.63	27.5	.74	.73	.71	.71	39	88	72	33	78	65	186	30	...	90	60	...	435	I
		Port		265	105	31.5	92	38	10.87	11.5	36.8	26	.74	.73	.71	.71		80		34	80	90	246	18	30	18	24	52		
6-n	11'16	St'b'd	261	255	165	57	82.5	31.5	7.5	8.75	28.96	27	.74	.73	.71	.71	39	92	70	33	82	70	195	24	...	90	60	...	410	I
		Port		250	170	57	86	31.5	7.5	9.55	30.8	27.5	.74	.73	.71	.71		76		34	58	72	105	14	...	52	27	60	28		
7-s	11.37	St'b'd	242	235	165	57	88	36.25	9.25	9.78	32.87	28	.74	.73	.71	.71	39	92	68	33	72	65	110	100	50	60	...	400	I
	P. M. 12'10	Port		240	185	58	88	41.2	11.68	12.38	38 9	27	.74	.73	.71	.71		78		34	58	80	100	26	...	64	24	52	24		
8-n		St'b'd	248	240	175	55	71.3	29.06	7.31	7.31	25.92	28	.74	.73	.71	.71	39	90	72	33	72	80	180	26	...	60	40	50	390	I
		Port		248	175	55	78.8	27.38	7.3	7.94	26.61	27	.74	.73	.71	.71		78		34	57	74	100	16	...	40	16	54	28		
9-s	12'30	St'b'd	187	173	168	57	75	30.75	7.41	7.88	27.29	28	.74	.73	.71	.71	42	90	68	33	78	115	186	24	...	60	40	50	...	...
		Port		230	145	40	84.5	32	8.38	9.06	29.97	28	.74	.73	.71	.71		76		34	60	73	115	202	16	...	40	22	54	20		
10-n	1'00	St'b'd	245	237	140	40	50.5	16.13	6.38	6.13	18.63	28	.74	.73	.71	.71	45	88	68	34	72	70	115	170	20	...	40	60	...	...
		Port		240	140	37	53.8	17.12	6.81	6.81	19.25	27	.74	.73	.71	.71		76		34	48	78	115	246	14	...	58	26	68	28		
11-s	1'27	St'b'd	259	240	155	40	49	16.25	6	5.81	17.46	28	.74	.73	.71	.71	44	90	67	34	68	70	180	18	...	60	40	60	...	...
		Port		260	150	38	53.3	18	6.84	7	19.59	27	.74	.73	.71	.71		75		34	50	78	120	248	14	...	60	26	68	30		
12-n	2'16	St'b'd	238	240	90	25	30.5	9.38	3.48	3.31	10.32	28	.74	.73	.71	.71	44	86	68	34	65	95	140	16	...	70	45	68	...	...
		Port		244	73	18	33.8	10	3.81	3.13	10.97	26.5	.74	.65	.71	.71	43	77		34	100	100	140	14	...	64	28	68	32		
13-s	2'34	St'b'd	245	235	105	25	33.8	11.44	3.72	3.41	11.61	28	.74	.65	.71	.71	44	86	66	35	66	100	150	120	14	...	60	50	...	...
		Port		240	83	18	33.5	10	3.63	3.44	11.07	26.5	.74	.6	.71	.71		70		36	48	132	150	244	14	...	60	26	64	28		
14-n	2'55	St'b'd	234	230	55	15	19.5	4.84	1.58	2	5.87	28	.74	.65	.71	.71	45	90	66	35	66	100	140	120	12	...	40	60	...	...
		Port	231	230	58	14.5	19.3	5.63	1 69	1.81	6 04	26	.74	.6	.71	.71		75		36	42	131	140	232	12	...	26	62	28		
15-s	3'18	St'b'd	232	230	45	15	17 88	4.75	1 63	1.7	5.49	28	.74	.65	.71	.71	45	85	66	35	65	100	180	140	10	...	40	60	...	...
		Port	216	216	46	13.5	6.5	5	1.69	1.56	5.93	26.25	.74	.6	.71	.71		68		36	40	130	120	228	10	...	24	54	28		


U. S. S. CHATTANOOGA.
Revolution and Indicated Horsepower Curve
constructed from data of progressive runs
over measured mile course off
NEWPORT, R.I
December 31 1904.
Plate 2
Combined mean curve (both engines) of revolutions & IHP
Port engine
Starbrd engine
Revolutions
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
70
80
90
100
110
120
130
140
150
160
170
180

After getting under way, water amounting to 44 tons was taken on board so as to insure a draught, when commencing the standardization runs, corresponding to a displacement of 3,200 tons.

The result of the trials with and against the tide (speed and mean revolutions) is plotted (dotted lines, Plate 1) as separate curves, and the curve of true speed constructed therefrom. From this latter curve, the deduction is made that an average of both engines of 179.7 revolutions per minute is requisite for a speed of 16.5 knots of the vessel.

On Plate 1 is also plotted curves of speed and indicated horsepower, and the mean curve obtained in the same manner as the mean curve for speed revolutions.

It is to be noted that points determined from runs Nos. 5 and 7, on the speed-revolution curve, fall so far without a fair curve running through other determined points as to indicate an abnormal condition when those runs were made. The cause is probably to be found in some diversity of the tide, due, possibly, to contour of the land, islands, etc., in the vicinity of the measured course.

Curves of revolutions and indicated horsepower, on the progressive runs are plotted and shown on a reduced scale in Plate 2. The curve for each engine (in dotted lines) is the mean for North and South runs, and the upper curve (shown in full) is the mean for both engines. From these curves, Tables III and IV have been constructed.

OFFICIAL FOUR-HOURS' CONTRACT TRIAL.

On January 1, 1905, at 9·15 A. M., the ship got under way from Newport, R. I., and proceeded to sea. The trial began at 11·50 A. M. and was finished at 3·50 P. M. The course steered was South 3 degrees West for two hours, when a long turn to the Westward was made and the course changed to North 3 degrees East. A moderate breeze was blowing from W. by N., with a moderate swell from the Southwest.

Before getting under way for the trial the mean draught was found to be 15 feet and 10 inches, corresponding to a displace-

TABLE III.

U. S. S. *CHATTANOOGA.*

Data Deduced from Progressive Runs over Measured-Mile Course, off Newport, R. I., December 31, 1904.

Revolutions per minute.	Speed in knots per hour.	Indicated horsepower.			Slip of propeller in per cent. of its own speed.*	Constant †
		Starboard engine.	Port engine.	Total both engines.		
60	6.09	83	102	185	12.03	9.852
65	6.6	125	130	255	12	9.848
70	7.1	160	155	315	12.09	9.859
75	7.61	200	189	389	12.06	9.855
80	8.12	240	225	465	12.05	9.852
85	8.61	280	265	545	12.21	9.872
90	9.09	325	305	630	12.47	9.901
95	9.57	378	360	738	12.7	9.927
100	10.05	430	415	845	12.9	9.951
105	10.53	495	483	978	13.08	9.971
110	10.97	560	553	1,113	13.57	10.029
115	11.43	630	630	1,260	13.86	10.061
120	11.87	705	710	1,415	14.27	10.11
125	12.3	785	800	1,585	14.72	10.163
130	12.73	872	891	1,763	15.13	10.212
135	13.15	970	1,000	1,970	15.58	10.266
140	13.55	1,081	1,116	2,197	16.12	10.332
145	13.96	1,200	1,245	2,445	16.56	10.386
150	14.36	1,330	1,385	2,715	17.03	10.445
155	14.75	1,476	1,540	3,016	17.53	10.508
160	15.13	1,633	1,715	3,348	18.05	10.575
165	15.5	1,805	1,913	3,718	18.58	10.645
170	15.84	1,990	2,130	4,120	19.27	10.732
175	16.2	2,200	2,375	4,575	19.77	10.803
180	16.53	2,425	2,645	5,070	20.41	10.889
185	16.87	2,663	2,936	5,599	20.97	10.966

*Slip of propeller in per cent. of its own speed, based on mean (11 feet $8\frac{1}{16}$ inches) pitch

$$= \frac{(P \times R) - \left(S \times \frac{6{,}080.27}{60}\right)}{P \times R} \times 100.$$

† Requisite number of revolutions of the engines per minute to drive the ship one knot per hour.

ment of 3,225 tons. On anchoring at 6 P. M., after the trial, the mean draught was 15 feet $8\frac{1}{2}$ inches, and the corresponding displacement 3,189 tons.

During the trial the main machinery ran without appreciable vibration, and its performance was satisfactory. No water was used on any bearings, except the H.P. and I.P. crosshead journals of both engines, which ran slightly warm. All auxiliary machinery worked well with the exception of a derangement of the valve gear of one of the auxiliary feed pumps.

TABLE IV.

U. S. S. *CHATTANOOGA.*

Data Deduced from Progressive Runs over Measured-Mile Course off Newport, R. I., December 31, 1904.

Speed in knots per hour.	Revolutions per minute.	Indicated horsepower.			Slip of propeller in per cent. of its own speed.	Constant, R ÷ S.
		Starboard engine.	Port engine.	Total both engines.		
6	**59**	**80**	**100**	**180**	**11.86**	**9.833**
6.25	61.45	96	110	206	11.85	9.832
6.5	64	118	125	243	11.98	9.846
6.75	66.5	135	135	270	12.03	9.851
7	**68.85**	**155**	**150**	**305**	**11.88**	**9.836**
7.25	71.43	170	165	335	12.03	9.852
7.5	73.8	195	185	380	11.92	9.84
7.75	76.38	205	195	400	12.06	9.855
8	**78.8**	**228**	**215**	**443**	**12.01**	**9.85**
8.25	81.4	250	235	485	12.16	9.866
8.5	83.85	270	250	520	12.14	9.865
8.75	86.5	295	275	570	12.33	9.886
9	**89.05**	**317**	**296**	**613**	**12.41**	**9.894**
9.25	91.63	344	323	667	12.51	9.906
9.5	94.22	369	350	719	12.61	9.918
9.75	96.85	395	380	775	12.75	9.933
10	**99.4**	**425**	**410**	**835**	**12.81**	**9.94**
10.25	102.14	458	443	901	13.03	9.965
10.5	104.76	490	478	968	13.13	9.977
10.75	107.48	524	515	1,039	13.32	9.998
11	**110.24**	**562**	**555**	**1,117**	**13.52**	**10.022**
11.25	113	600	596	1,196	13.72	10.044
11.5	115.8	643	643	1,286	13.93	10.070
11.75	118.68	684	686	1,370	14.19	10.1
12	**121.48**	**726**	**735**	**1,461**	**14.39**	**10.123**
12.25	124.4	776	786	1,562	14.66	10.155
12.5	127.25	826	840	1,666	14.86	10.18
12.75	130.23	880	898	1,776	15.15	10.214
13	**133.24**	**939**	**964**	**1,903**	**15.44**	**10.249**
13.25	136.23	1,000	1,029	2,029	15.71	10.282
13.5	139.22	1,065	1,100	2,165	15.96	10.313
13.75	142.38	1,138	1,179	2,317	16.3	10.355
14	**145.48**	**1,215**	**1,258**	**2,473**	**16.6**	**10.391**
14.25	148.63	1,295	1,345	2,640	16.91	10.43
14.5	151.73	1,380	1,440	2,820	17.18	10 464
14.75	155	1,476	1,540	3,016	17.53	10.508
15	**158.25**	**1 576**	**1,650**	**3,226**	**17.85**	**10.55**
15 25	161.65	1,688	1,776	3,464	18.24	10.6
15.5	165	1,805	1,913	3,718	18.58	10.645
15.75	168.56	1,938	2,066	4,004	19.02	10.702
16	**172.1**	**2,078**	**2,232**	**4,310**	**19.43**	**10.756**
16.25	175.75	2,234	2,419	4,653	19.87	10.815
16.5	179.7	2,410	2,625	5,035	20.42	10.89
16.75	183.2	2,575	2,828	5,403	20.76	10.937

The boilers steamed freely, and the automatic regulation of the firing, as well as the excellent organization of the fireroom force, contributed largely to the success of the trial. A timing apparatus for firing was improvised on board ship by Lieutenant A. T. Graham (the Chief Engineer), and proved so efficient in practical operation that a brief description may not be out of place. It consisted of a wooden annular ring, about an inch in width, placed on the face of a fireroom clock. In this, circumferentially, at equal intervals, fifty-four brass brads were driven, and every sixth one connected in circuit by wires set in the back of the ring. The minute hand of the clock had attached to it a small piece of wire which in revolving engaged, successively, the brass brads, and thus completed, when thrown in for operation, electrical contact through the dynamo circuit. A wooden box with transparent sides was hung between the firerooms, containing six 5-candlepower lights, arranged in compartments one above the other; when these lighted there was displayed consecutively the numbers 1, 2, 3, 4, 5, 6, which were continuously repeated at regular intervals, and which were visible to both firerooms. The furnaces—two boilers—in each fireroom were numbered from 1 to 6, and marked in an athwartship direction as shown:

BOILER B.		BOILER A.
2 - 5 - 3	*Forward Fireroom.*	4 - 6 - 1
1 - 6 - 4		3 - 5 - 2
BOILER D.		BOILER C.
BOILER F.	*After Fireroom.*	BOILER E.
2 - 5 - 3		4 - 6 - 1

From the above it will be observed that the firing interval was $1\frac{1}{2}$ minutes. The firemen were instructed to spread evenly over the grate six shovels-full of coal at each firing, and to fire only when the number of their furnace was displayed. In addition, a height of six inches above the grate was marked with aluminum paint on the furnace door front of each furnace, so that the height of the fire might be readily judged at any time. Instructions were given to fire less coal than the amount stated,

if the fire exceeded six inches in height, and more if the reverse was the case. The only other instructions necessary were as to levelling the fires, which was always done (with a "devil's claw") just before firing each furnace. For example, when No. 1 fired and closed the furnace door, No. 2 immediately and quickly levelled and stood by to fire when his light came up, particular care being exercised, at all times, to keep furnace doors open no longer than absolutely necessary.

No slice bars were used during the trial.

The mean average revolutions for both engines, during the four-hours' run was 181.8, and the speed per hour, as deduced from the speed-revolution curve, 16.65 knots, or an excess of .15 knot over the contract requirements. Revolutions of each main engine were taken by two counters, separately connected, at 15-minute intervals; maximum and minimum revolutions for such periods are as shown below:

	Starboard.	*Port.*
Maximum revolutions, main engines	184.6	184.7
Minimum revolutions, main engines	179.0	179.5

PERFORMANCE.—FOUR HOURS' OFFICIAL TRIAL.

Steam Pressures. (*Average of one-half hourly observations.*)

	Starboard.	*Port.*
Steam pressure at boilers (per guage), pounds	269.4	
H.P. steam chest (gauge), pounds	238	238
1st receiver (absolute), pounds	100.6	105.8
2d receiver (absolute), pounds	31	36
Vacuum in condensers, inches of mercury	25.94	25.43

Temperatures. (*Average of one-half hourly observations.*)

	Starboard.	*Port.*
Injection, degrees	39.8	39.8
Discharge, degrees	80	77.6
Hotwell, degrees	80.4	77.1
Feed-water, degrees	130	117.6
Engine room, upper platform, degrees	101	101
working platform, degrees	83.3	75.1
Firerooms, above grating, degrees	94	
working level, degrees	88.6	

Revolutions, or double strokes, per minute. (*Average of one-half hourly observations.*)

Main engines (mean for trial)	182	181.6
average for both	181.8	
Pumps, main, air	Attached.	
circulating	173.7	227.2
feed (forward and after)	27	18.1
hotwell	72.5	42.5
bilge	60	40.8
water service	50	20.3
auxiliary, feed	...	20
condenser	...	23.2
Blower engines, starboard, forward	493	
port, forward	497	
after	500.2	
Speed of ship, in knots per hour	16.65	
Slip of propeller, in per cent. of its own speed, based on mean pitch and average speed	20.71	20.57
Air pressure in firerooms, inch of water	1	

Mean effective pressures in cylinders, in pounds per square inch. (*Averages of cards taken at half-hourly periods.*)

Main engines, H.P. cylinder	116	115.56
I.P. cylinder	51.44	54.62
F.L.P. cylinder	15.58	16.22
A.L.P. cylinder	15.43	17.40
Mean equivalent pressure, in pounds per square inch, referred to combined area of L.P. pistons	47.16	49.47

INDICATED HORSEPOWER.

Main engines, H.P. cylinder	788.5	783.8
I.P. cylinder	925.6	980.8
F.L.P. cylinder	421.8	438.2
A.L.P. cylinder	417.8	470.1
Total	2,553.7	2,672.9
both engines	**5,226.6**	

AUXILIARIES.

Circulating pumps, main	12.5	26
Feed pumps (main and auxiliary)	38.	
Hotwell pumps	5	3
Bilge pumps	1.2	.5
Water-service pumps	2.3	.7
Auxiliary condenser pumps	...	1.2
Blower engines (forced draft)	45.	
Steering engine (estimated)	3.	
Dynamo engine (one in operation)	31.	
Total	**169.4**	
Total all machinery in operation	**5,396.0**	

COAL.

Kind and quality	Pocahontas, hand-picked, excellent.
Value in B.T. units (by calorimetric tests)	15,165
Pounds, per hour	10,632.1

DEDUCED DATA.

I.H.P. (total) per square foot of grate surface	17.99
heating surface	.4088
Pounds of coal per I.HP. per hour (main engines only)	2.03
all machinery in operation,	1.97
Pounds of coal per square foot of grate surface	35.44
heating surface	.8055
Cooling surface (main condenser), square feet per (total) I.H.P.	1.11

ENDURANCE TRIAL.

On completion of the four-hours' trial, it was the intention to make a 24-hour endurance run at about two-thirds horse-power, to determine reliable data concerning speed, coal consumption, and general efficiency of the machinery. For this purpose, the vessel got under way from Newport, R. I., about 1·30 P. M., January 3, 1905, and the trial began at 2·30 P. M. The weather was cloudy and rainy, and the wind fresh and increasing from the Northeast, with a moderate sea from the same direction. By 11 P. M. the wind had increased to a moderate gale, with a corresponding increase in sea, making it necessary to slow down, both on account of the amount of water taken over the bow and the thickness of the weather. The trial was, therefore, abandoned. Important data collected during eight hours of this trial is given below:

PERFORMANCE—ENDURANCE TRIAL.

Date and hour	January 3, 1905, 2.30 to 10.30 p. m.		
Number of hours	8		
	Starboard.		*Port.*
Mean revolutions of engines	157.9		157.5
both engines		157.7	
Steam pressure in boilers, pounds, per square inch,		255.	
at engines, pounds, per square inch,		244.	
H.P. steam chest, absolute	219.5		237.5
1st receiver, absolute	87.5		98.5
2d receiver, absolute,	31		35.5
Steam cut-off H.P. cylinder from beginning	.52		.58

Steam cut-off I.P. cylinder from beginning	.59	.60
F.L.P. cylinder from beginning	.47	.52
A.L.P. cylinder from beginning	.47	.47
Vacuum, in inches of mercury	26.5	26.75
TEMPERATURES.		
Injection	44	
Discharge	78	77
Feed-water	143.5	135
MEAN EFFECTIVE PRESSURES.		
Main engines, H.P. cylinder	77	82.4
I.P. cylinder	34.2	36.7
F.L.P. cylinder	12.82	16.25
A.L.P. cylinder	12.3	14.11
M.E.P. referred to L.P.'s	33.6	37.73
INDICATED HORSEPOWER.		
Main engines, H.P. cylinder	454.1	484.8
I.P. cylinder	534	571.5
F.L.P. cylinder	301.1	380.8
A.L.P. cylinder	288.9	330.6
	1,578.1	1,767.7
Total, both engines	**3,345.8**	
I.H.P. of all auxiliaries in operation	**122**	
Total, all machinery in operation	**3,467.8**	
Grate surface in use	300	
Pounds of coal used per hour	5,947.4	
per square foot of grate,	20.12	
per I.H.P. per hour (main engines),	1.78	
all machinery in operation	1.72	
Mean draught at beginning of trial, feet and inches,	15–11¼	
speed, by curve, in knots per hour	14.93	
Slip of screw, per cent	17.95	
Average air pressure, in inches of water	.5	

NOTES.

WARSHIP BUILDING IN 1904.

Largely owing to reduced production from the private yards, the tonnage of warships launched during the year now closing is considerably less than in the previous year, and is much below the average of the past seven years. During that period the fighting ships launched from all British yards, for foreign navies as well as our own, made up a total of over 1,000,000 tons, or an average of 145,000 tons per annum; and the forty vessels floated during 1904 make up collectively a displacement tonnage of only 127,452 tons. So far as the dockyards are concerned, the output is well up to the average, notwithstanding that extensive work has been carried out in connection with repairs and overhauls. The reduction in the work allotted to private firms is very marked, the tonnage launched being little more than one-half what it was for the British Navy in 1903, while in 1901 the total was more than double the tonnage of 1904. This question of the relative proportion of work allotted to the Royal establishments and to private firms has aroused attention during the past year, and the figures seem to justify the grievance expressed by such firms who have laid themselves out to satisfy Admiralty requirements, both in respect to efficient workmanship and time of delivery, and who are now short of naval orders. In 1903 three battleships were to have been ordered from contractors; but these at the last moment were given to the dockyards, the promise being made that there would be compensatory work for private firms in the succeeding year. But during the twelve months now closing only two battleships have been ordered from private firms, and no cruisers, the dockyards getting three cruisers. It is generally accepted that new work can be more economically carried out by contract than in the Government works, for the unavoidable reason that the conditions required

for repair work are inimical to economical new construction. In the one case the plant requires to be distributed over a wide area, so that machine work for ships in docks, often widely separated, can be carried out close to the vessel so as to reduce handling; whereas with new construction the machine tools are preferably concentrated at the building berths. This

TABLE I.—FIGHTING VESSELS LAUNCHED.

.....	No.	Tons.	Indicated horse-power.	Value of ships completed.
In 1904, dockyards	4	57,100	80,500	£4,660,000
private yards (H.M.S.)	31	67,552	279,500	6,015,000
(foreign)	5	2,800	3,200	62,000
Total in 1904	40	127,452	363,200	10,737,000
In 1903, dockyards	4	28,290	42,800	2,384,000
private yards (H.M.S.)	31	120,456	277,300	9,848,000
(foreign)	7	4,237	17,190	368,000
Total in 1903	42	152,983	337,290	12,600,000
In 1902, dockyards	5	51,560	77,000	3,723,000
private yards (H.M.S.)	10	40,494	108,000	3,208,000
(foreign)	7	990	8,550	145,000
Total in 1902	22	93,044	193,550	7,076,000
In 1901, dockyards	8	64,910	114,300	4,901,200
private yards (H.M.S.)	24	144,190	275,000	11,002,600
(foreign)	7	2,442	47,500	340,000
Total in 1901	39	211,542	436,700	16,243,800
In 1900, dockyards	4	5,230	11,200	394,600
private yards (H.M.S.)	17	30,374	125,800	2,531,600
(foreign)	8	25,827	42,750	1,925,000
Total in 1900	29	61,431	179,750	4,851,200
In 1899, dockyards	6	66,900	78,000	4,901,100
private yards (H.M.S.)	12	53,222	111,000	3,791,000
(foreign)	16	47,170	124,000	3,767,000
Total in 1899	34	167,292	313,000	12,459,100
In 1898, dockyards	8	70,955	84,800	4,441,000
private yards (H.M.S.)	22	70,033	168,800	4,242,000
(foreign)	18	52,365	144,250	3,480,000
Total in 1898	48	193,353	397,850	12,163,000

partly explains the lack of economy; there is, too, the difference in working hours, and in the amount of work done by the Government workers, as compared with that by private employés. The time is coming when it may be advisable to give all new warship work to contractors. The saving to be effected would be from 10 per cent. to 15 per cent., which in the aggregate would quite equal each year the cost of one of the largest type of destroyers.

But to return to the work of the year, it will be seen from Table I, that thirty-five ships for the King's Navy were launched from the various yards throughout the kingdom. These have a collective tonnage of 124,652 tons, while the indicated horsepower of the machinery aggregates 360,000. In the previous year there were thirty-five vessels, making up a total of 148,746 tons, the horsepower being 320,100. There is thus a decrease of 14,000 tons, but owing to the inclusion this year of a larger number of high-speed destroyers, the indicated horsepower is about 40,000 greater; 1902 was a lean year, the tonnage launched then being only 92,000. The best year in recent times was 1901, when the total was 209,000. Fewer large ships were floated this year, the list including only two battleships; whereas there were six in 1903; five cruisers, all of the armored type were floated, as compared with four in the previous year; two third-class cruisers, six scouts, one gunboat thirteen torpedo-boat destroyers, a torpedo boat, three improved and enlarged submarines, and two coast-guard cruisers, making up a total of thirty-five, including every type of the modern fleet.

As shown in Table II, the dockyard tonnage is 10,000 tons above the average of the preceding fourteen years; but at the present time the tendency is to reduce the staff at the Royal establishments, and we hope, for reasons we have already expressed, that the time is coming when these concerns will be confined to repair work. In the previous year a large amount of such repair work was given out to contract, ships as a rule being sent to the works where they were originally built; but, owing to the extreme difficulties of preparing a comprehensive esti-

mate and of subsequent accounting, the financial arrangements have not, it is said, been satisfactory to the Treasury, so that from all points of view the dockyards would be more suitably employed in carrying out such repair work than in new construction. In the United States the experiment was made of building in competition a battleship in one of the Government yards and a second in private works, and the result, as might have been anticipated, was so much in favor of contract work that the former practice of giving no new work to Government establishments will be maintained.

TABLE II.—FIFTEEN YEARS' PRODUCTION OF BRITISH NAVY SHIPS.

Year.	Dockyard.		Private yard.		Total.	
	No.	*tons.*	*No*	*tons*	*No.*	*tons.*
1890	8	22,520	13	42,475	21	64,995
1891	8	68,100	10	39,150	18	107,250
1892	9	50,450	13	90,750	22	141,200
1893	9	32,400	5	1,919	14	34,319
1894	8	26,700	19	4,825	27	31,525
1895	8	70,350	28	66,412	36	136,762
1896	9	70,970	26	36,515	35	107,485
1897	4	31,885	22	34,111	26	65,996
1898	8	70,955	22	70,033	30	140,988
1899	6	66,900	12	53,222	18	120,122
1900	4	5,230	17	30,374	21	35,604
1901	8	64,910	24	144,190	32	209,100
1902	5	51,560	10	40,494	15	92,054
1903	4	28,290	31	120,456	35	148,746
1904	4	57,100	31	67,552	35	124,652
Totals.....	102	718,320	283	842,478	385	1,560,798

Of a total average of about 104,000 tons per annum the private yards contribute 56,100 tons and the dockyards 47,900 tons. The dockyards, however, are at the moment very fully occupied, the four yards now engaged on new construction work having yet to float 90,050 tons, as compared with 114,000 tons a year ago and 68,390 tons two years ago. Portsmouth constructed the only two battleships included in this year's total, while, of the two armored cruisers, Chatham launched the *Devonshire* and Pembroke the *Duke of Edinburgh*. Devonport did not float any vessels, but has a battleship in a fairly advanced state, and a cruiser is being laid down. Chatham has similar ships in hand; and at Pembroke two armored

cruisers are in hand, one of them almost ready for launching. A better method of indicating the extent of work done is, perhaps, to take the production of the yards over a period of years, and this is done in Table III.

TABLE III.—THE PRODUCTION FROM EACH NAVAL YARD.

Yard.	1904.		1903.		Total for 15 years.	Average for 15 years.
	No.	*tons.*	*No.*	*tons.*	*tons.*	*tons*
Portsmouth	2	32,700	1	9,800	206,131	13,742
Chatham	1	10,850	...	...	191,212	12,747
Devonport	...	...	1	16,350	148,768	9,917
Pembroke	1	13,550	...	...	141,470	9,431
Sheerness	...	...	2	2,140	31,299	2,086

The work done by private yards is much less than in several previous years, excepting 1902 and 1900. This, of course, is taking into account the foreign work done, the only vessels launched this year, other than those for the British Navy, being a Canadian cruiser built by the Vickers Company, and three boats constructed by Messrs. Yarrow. But there is on hand, fortunately, a greater amount of foreign warship tonnage than has been the case for three or four years. The total tonnage of the warships built in private yards this year is only 70,352, whereas in the previous year it was 124,700 tons; in 1901, 146,600 tons; in 1900, 56,000 tons; in 1899, 100,000 tons; and in 1898, 122,000 tons. These figures speak for themselves, and indicate that if firms are to be encouraged to retain berths for warship work—which berths require to be of specially sound character, owing to the concentration of load in short, beamy battleships and cruisers—then the Admiralty should offer greater consideration to the question of the respective claims of dockyards and contractors.

As to the design of the battleships built we do not propose to enter into details, especially as we have in past issues referred to the widely-entertained opinion that many of our modern ships are weak in ordnance, because they have too many guns of small caliber, recent war operations having shown that the strongly-held opinion in favor of long-range

guns is correct. The two battleships belong to the *King Edward VII* class, of which five were launched in the preceding two years. Of these, four have now completed their trials, and in all cases the legend speed of 18½ knots has been exceeded by practically half a mile per hour. To these and other trials we shall refer in a subsequent article. There are two more of the class yet to launch—the *Hibernia* and the *Africa*—building respectively at Devonport and Chatham. There will thus be eight vessels of the same class, whose efficiency would be enormously enhanced by the substitution of more 9.2-inch or of some 7.5-inch guns in place of the ten 6-inch weapons now fitted. They have a displacement tonnage of 16,350 tons and engines of 18,000 horsepower. The dockyard ships will cost over £1,400,000, or £60,000 more than the sister ships built by the contractors.

Of the five cruisers launched, the *Devonshire*, floated at Chatham, the *Roxburgh*, launched by the London and Glasgow Company, and the *Argyll*, by Scott's Shipbuilding and Engineering Company, of Greenock, belong to the improved County class, with 6-inch armor on the broadside, having a total displacement of 10,850 tons, and machinery of 21,000 horsepower, to give a speed of 23 knots. The other two cruisers—the *Black Prince* and the *Duke of Edinburgh*—are the first vessels designed by Mr. Philip Watts as Director of Naval Construction, and are considerable advances upon even the improved County class. But Mr. Watts, in his *Minotaur* class, has done very much better, as in them the 6-inch gun has been entirely discarded, the armament consisting of four 9.2-inch guns and ten 7.5-inch guns, whereas in the *Black Prince* there were six 9.2-inch and ten 6-inch guns. We recently entered at length into the question of the gun power of our cruisers, and we need not enlarge upon the serious defects of many of the vessels not yet completed.

Little requires to be said about the third-class cruisers, of which two were built similar to two launched in the preceding year. These four vessels—the *Diamond* and *Topaze*, built by Messrs. Cammell, Laird & Co.; the *Sapphire*, built by Palmers'

Shipbuilding and Iron Company; and the *Amethyst*, built by Sir W. G. Armstrong, Whitworth & Co.—have all completed their trials; and as the *Amethyst* was fitted with Parsons steam turbine, opportunity was afforded of making a comparison of this newer motor against the ordinary reciprocating machinery fitted in the others. There was the minimum number of variants, so that a fairly safe deduction could be made as regards economy, and the results—which we published in considerable detail some weeks ago—showed clearly that for practically all powers the turbine machinery is more economical, the difference being greatest at the highest rates of speed, when the steam consumption of the turbines was about 30 per cent. less than with the reciprocating engines.

Six of the new 25-knot scouts have been launched. Of these, two—the *Pathfinder* and *Patrol*—were built by Messrs. Cammell, Laird & Co., Birkenhead; two—the *Forward* and *Foresight*—by the Fairfield Company; one—the *Sentinel*—by the Vickers Company, and the sixth—the *Adventure*—by Sir W. G. Armstrong, Whitworth & Co. The two last-named firms have each a sister ship to launch, but are very properly awaiting the results of trials. The *Sentinel* is the only one completed, and will proceed on her final trials within a few weeks. Already some experimental tests have been made which have given very promising results. The design of the machinery of these vessels is of very considerable interest, because of the limitation in weight, notwithstanding the 17,000 horsepower to be developed. In some of them very light torpedo-destroyer machinery has been adopted, and Messrs. Hawthorn, Leslie & Co., who are engining the Elswick boats, are fitting on each shaft two independent sets of triple-expansion engines, making six cylinders in all. In the Vickers ship the engines are substantial, and resemble more the cruiser type, so that a comparison of the results of the trials of all ships, and especially of the endurance of the machinery, will certainly be of considerable interest.

Thirteen destroyers were launched, all of the new 25½-knot class. Three of these—the *Ure*, *Wear* and *Rother*—were built

by the Palmer's Company; three—the *Boyne*, *Doon* and *Kale*—by Messrs. Hawthorn, Leslie & Co.; two—the *Ribble* and *Welland*—by Messrs. Yarrow; two—the *Liffey* and *Moy*—by Messrs. Cammell, Laird & Co.; two—the *Jed* and *Chelmer*—by Messrs. Thornycroft; and one—the *Ness*—by Messrs. J. S. White & Co., of Cowes. Their displacement was from 580 to 600 tons. These vessels, which have high forecastles, were undoubtedly ordered under a misconception. Following upon the accident to the *Cobra*—a vessel of 30 knots—a courtmartial raised doubts, on imperfect knowledge, as to the strength of the 30-knot destroyers, and for this reason scantlings and weights were increased, with the result that speed had to be reduced, and now even 25½ knots is only attained with considerable difficulty.

A committee of experts, appointed subsequently to the courtmartial, made a most searching investigation, and a series of interesting experiments at sea with 30-knot boats, and their report, which unfortunately has not yet been issued, is understood to prove that the doubts raised by the decision of the courtmartial were baseless. Now the Admiralty propose to construct destroyers to attain a speed of 32 to 33 knots. The builders invited to tender have been left a free hand as to the design and the system of propulsion; but it would almost appear that the turbine is practically essential to the attainment of this very high rate of speed. In view, however, of the fact that at low power considerable difficulty is experienced in attaining a high economy in turbine-driven destroyers, it is probable that in high-speed turbine craft reciprocating engines will be fitted forward of the turbines for cruising purposes, and perhaps also for going astern; but it is yet too early to indicate the exact nature of the proposals put forward for the consideration of the Admiralty. A torpedo boat was also built by Messrs. J. S. White & Co., of Cowes, and the shallow-draft gunboat *Widgeon* by Messrs. Yarrow. The coastguard ships by Messrs. Workman, Clark & Co., of Belfast, and by Messrs. Bow, McLachlan & Co., of Paisley.

Three more submarines have been added to our fleet from

the Vicker's Company's works, but patriotism justifies our referring to these only in very general terms. It is very satisfactory to know that the resources of this important constructional firm—perhaps the most progressive in the country—have been placed unreservedly and exclusively at the disposal of the Admiralty in this matter; and the best results are the more likely to be achieved by the ready co-operation between the inventive engineers of the company and the officers of the Navy most qualified for this by experience and knowledge of the problems of submarine navigation. The consequence of practical work with these new engines of naval warfare is that the British type of boat has many qualities which, it is understood, are lacking in the boats of foreign navies. We have the assurance of the Admiralty that most satisfactory results are being achieved, and since secrecy in the design and equipment of these vessels is of the most vital importance to the maintenance of our naval power, all will regard this assurance, even in the absence of definite evidences, as meeting the special circumstances of the case.—"Engineering," London.

WARSHIP STEAM TRIALS IN 1904.

There were rather fewer warships passed through their steam trials last year than in the immediately preceding years; but the list, as we shall presently show, is of considerable interest, because of the comparisons which can be made. In all there were twenty-six vessels, as compared with twenty-nine in the previous year, eighteen in 1902, thirty-two in 1901, and twenty-five in 1900. The list includes five battleships, one armored cruiser, four third-class cruisers, a torpedo gunboat, which had been re-engined, a sloop, a shallow-draught gunboat, nine destroyers, and four torpedo boats; whereas in the previous year there were four battle ships and eight armored cruisers, with about the same number of small craft, and ten destroyers and five torpedo boats. The results of the trials of the larger ships are set out in Table I, and we would direct special attention to the fact that we are able this year to include the water

consumption of the great majority of these vessels. The measurement of water on trials involves the expenditure of national money; but the result is an important element in arriving at the relative economy of different types of steam generators and of the machinery, and the Water-Tube Boiler Committee are to be commended for bringing about this change, so long desired by the engineering officers of the Admiralty and by engineers generally. In Table II the results of the trials of torpedo craft are given; in their case the limitations of space and weight, in association with the rapid rate of steam generation, precludes similar tests being made.

Of the five battleships on the list, one, the *Swiftsure*, was, with the *Triumph*, originally built for the Chilian Government, and the specification called for steam trials under Chilian conditions, so that, although the tests were made by Admiralty officials, the nature and duration of the trials differed from those usually provided for in British naval contracts. These were, however, of a sufficiently severe nature and duration to adequately test the steaming qualities of the ships. The *Swiftsure's* performance we have already analyzed and compared with those achieved by the *Triumph*, completed for commission by the Vickers Company, while pointing out their superiority in many of the combative elements, associated as they have proved to be with higher speed than that usually attained by British warships. It is gratifying to know that in service both of these ships are giving very satisfactory results, and that the Admiralty have, in the redistribution of the ships of the fleet, placed them, as they ought all along to have been placed, along with 19-knot vessels of the *Russell* class, to which they are superior in speed as well as in gunpower.

The other four battleships belong to the *King Edward VII* class, of which four more are being built. So far as the offensive and defensive qualities of these vessels are concerned we have already dealt fully with them, and are now only concerned with the results of the trials. The *Dominion* and one or two of the other vessels were tried under new conditions, closely approximating to those appertaining to war. These

conditions we have already reviewed at considerable length. The fact that they are feasible was demonstrated, perhaps more effectually in the case of the *Dominion* than in the other ships.

One point of interest in the comparison is that while the *Commonwealth* and *Dominion* are fitted entirely with Babcock and Wilcox boilers, the other two ships of the class included in Table I have a proportion of cylindrical boilers for use when steaming at low power, the water-tube boilers being intended for service at the higher rates of speed. This change was in conformity with the suggestion of the Navy boiler committee; but experience has shown that it is not quite satisfactory, and later ships are now fitted exclusively with water-tube steam generators. The results of the first 30-hours' trial, at one-fifth of the full power, are, from this point of view, suggestive. It will be seen that the two ships using water-tube boilers for this trial proved more economical from the point of view of coal consumption than the other two. Thus the water-tube boilers of the *Dominion* gave an evaporation of 11.2 pounds of water per pound of coal; while in the case of the *Hindustan* the result was 10.3 pounds, and in the case of the *King Edward VII* 7.6 pounds.

On the second 30-hours' trial, at three-quarters of the designed power—which, in the Navy, is regarded as the power which should be maintained so long as the coal in the bunkers may last—the results are more uniform, but the *King Edward VII*, again compares badly, while the Vickers ship proves exceptionally satisfactory, especially in respect of speed. The two ships fitted exclusively with water-tube boilers have again a lower consumption than the others, the *Commonwealth* coming out at 1.67 pounds, the *Dominion* at 1.68 pounds, whereas the rate for the *Hindustan* is 1.76 pounds, and for the *King Edward VII*, 1.96 pounds. The evaporative efficiency in the case of the *Dominion* is highest, being 11 pounds of water per pound of coal; but as the steam consumption of the machinery was higher than in the other ships, there may be some other cause partly accounting for the figures. In the

TABLE I.—RESULTS OF OFFICIAL STEAM TRIALS OF WARSHIPS MADE DURING 1904.

Name of vessel.	Type of ship.	Builders of ship.	Makers of machinery.	Length in feet.	Displacement.	Type of boilers.	Heating surface.	Grate area.	First 30-hours' trial.				Second 30-hours' trial.				Full power.			
									Indicated horsepower.	Speed, log.	Coal per I.H.P. per hour.	Water, all purposes, per I.H.P. per hour.	Indicated horsepower.	Speed, log.	Coal per I.H.P. per hour.	Water, all purposes, per I.H.P. per hour.	Indicated horsepower.	Speed. l = log. m = measured mile.	Coal per I.H.P. per hour.	Water, all purposes, per I.H.P. per hour.
					tons.		*sq. ft.*	*sq. ft.*		*knots*	*lbs.*	*lbs.*		*knots.*	*lbs.*	*lbs.*		*knots*	*lbs.*	*lbs.*
Swiftsure	Battleship	Armstrong	Humphrys, Tennant & Co.	436	11,800	Yarrow	37,524	664	8,700	17.217	2.39	...	...	...	...	...	14,031	19.93 l.	...	...
Commonwealth	Ditto	Fairfield Company	Fairfield Co.	425	16,350	Babcock & Wilcox	47,360	1,402	3,663	11	1.73	...	12,797	16 88	1.67	16 77	18,562	19.37 l.	1.83	18
Dominion	Ditto	Vickers Sons & Maxim	Vickers Sons & Maxim	425	16,350	Ditto	47,360	1,402.5	3,889	12.8	1.93	21.6	12,843	18.3	1 68	18.4	18,438	19.35 l	1.77	18.3
King Edward VII.	Ditto	Devonport	Harland & Wolff	425	16,350	Babcock and cylindrical	43,700	1,309	3,760	11.6	2.63	20	12,844	17.35	1.96	16.3	18,138	19.04 l.	2.17	17.7
Hindustan	Ditto	J. Brown & Co.	J. Brown & Co.	425	16,350	Ditto	47,564	1,364	3,718	11.8	1.94	20	12,926	17.65	1.76	17.5	18,521	19 8 l.	1.8	18.3
Cornwall	First-class cruiser	Pembroke	Hawthorn, Leslie & Co.	440	9,800	Babcock & Wilcox	54,826	1,616.5	4,798	15.3	1.73	17.8	16,498	21.83	1.69	17.45	22,709	23.8 l.	1.94	17.9
Amethyst	Third-class cruiser	Armstrong	Parsons (turbine)	360	3,000	Modified Yarrow	25,968	.494	4,890†	18.2	1.71	15.6	7,300†‡	20.63	1.5	13.8	14,200†	23.63 m	1.72	13.4
Sapphire	Ditto	Palmer's	Palmer's	360	3,000	Reed	26,010	496	5,012	18.47	2.34	19.8	7,281‡	20.68	2.22	19.8	10,200	22.45 m.	2.52	22.2
Diamond	Ditto	Laird's	Laird's	360	3,000	Laird-Normand type	26,000	490	5,074	18	2.27	19	7,143‡	20	2.32	19 31	10,066	22.17 m.	2.98	21.6
Topaze	Ditto	Ditto	Ditto	360	3,000		26,000	490	4,992	18.1	2.3	19.2	7,092‡	20.2	2.2	19.49	9,860	22.1 m.	2 65	20.2
Halcyon	Torpedo gunboat	Devonport	Re-engined and re-boilered; Cammell, Laird	250	1,070	Laird-Normand	13,530	240	1,280	12.6	2 6	...	1,288*	12.25	1.92	...	6,194	20.5 l.	...	...
Cadmus	Sloop	Sheerness	J. S. White	185	1,070	Niclausse	4,000	135 8	331	6	2.12	...	1,068	11	1.82	...	1,433	13.4 m	1.97	...
Widgeon	Shallow-d'ft. gunboat	Yarrow	Yarrow	160	180	Yarrow	2,654	95 2	...	...	...	...	...	...	...	...	671	13 m.	...	...

*Trial, 12 hours' duration. †Estimated indicated horsepower. ‡Trial, 8 hours' duration.

case of the *Commonwealth* and *Hindustan* 10 pounds of water were converted into steam per pound of coal, whereas in the case of the *King Edward VII* the result is again less—8.3 pounds. As regards the full-power trial, the interesting fact is that in all cases the designed power was exceeded, being in three cases practically 500 over the legend; the propulsive efficiency also seems to have been high. The designed speed was 18½ knots, but with the relatively slight increase in power 19.3 knots was realized, a result which must be regarded as very favorable. The *King Edward VII* was consistent in her high coal consumption, the rate at full speed being 2.17 pounds; the others range between 1.77 pounds and 1.83 pounds per horsepower hour. The evaporative efficiency in the case of the Vickers ship is again higher, being 10.3 pounds, whereas in the *Commonwealth* and *Hindustan* it is 10.3 pounds and 10.2 pounds, and in the *King Edward VII* it is once more very low—8.15 pounds. It would, of course, be a mistake to place too much reliance on these comparisons; although the results are taken with very great care, there must necessarily be a margin of inaccuracy; but against this there is the fact that the ships occupy the same relative positions to each other on each of the trials.

Of the cruisers the *Cornwall* is the only armored cruiser included in the list. She is the last of the ten vessels of the County class to be completed. The first vessels of the class, it will be remembered, did not at first obtain their legend speed of 23 knots; but when new propellers were fitted, having a larger ratio of blade area per unit of diameter, a great improvement was manifested, and this has been maintained by the *Cornwall*, which, on her full-power trial, attained a speed of 23.8 knots for 22,709 indicated horsepower, or 700 in excess of the designed power. The evaporation on the low-power and on the 75 per cent. trial, was 10.3 pounds per pound of coal; but on the full-power trial it dropped to 9.25 pounds. The steam consumption of the machinery—which, by the way, is of the short-stroke type—was uniform at about 17¾ pounds.

The four third-class cruisers in the list are remarkable for the inclusion amongst them of the first steam-driven turbine cruiser afloat. This vessel—the *Amethyst*—in all other respects closely resembles the *Sapphire*, *Diamond* and *Topaze*, so that the results are especially interesting. We have, however, so recently reviewed the performances of these four vessels that it is not necessary here to enter at length into the question. The figures given may vary slightly from those already published, as those given in Table I have been subjected to a more careful analysis than was possible on the ships themselves, but the general result is the same. At one-half power the turbines required only 15.6 pounds of steam per horsepower, as compared with an average of 19.3 pounds by the other three ships; at three-quarters power the steam consumption dropped to 13.8 pounds, as compared with 19.5 pounds; while at full power the steam consumption was only 13.4 pounds, as compared with a mean of 21.3 pounds. The coal consumption per unit of power was less for the turbine boat, probably because the steam evaporation per square foot of surface was not so high. For the same weight it was possible to develop 4,000 horsepower more than with the reciprocating engines, so that the speed was 1¼ knots greater—the *Amethyst* recording on her measured-mile performance 23.63 knots, while the other three vessels ranged between 22.1 and 22.45 knots.

Little need be said of the other three ships in the list. One is a torpedo gunboat—the *Halcyon*—built under the Naval Defense Act scheme in 1894. She was then fitted with locomotive boilers, which gave a speed of only 19 knots; but now, with water-tube boilers and new machinery, she has succeeded in increasing her power from 3,500 to 6,194, attaining a speed according to log of 20.5 knots. The *Cadmus* is a sloop, and the results generally compare with those attained on similar vessels; while the *Widgeon* is a shallow-draught gunboat by Messrs. Yarrow, for service on the China rivers. This vessel we have already described, and dealt also with her trials.

TABLE II.—RESULTS OF OFFICIAL TRIALS OF TORPEDO-BOAT DESTROYERS AND TORPEDO BOATS MADE DURING 1904.

Name of vessel.	Makers of hull and engines.	Length.	Displacement.	Type of boiler.	Heating surface.	Grate area.	Four-hours' speed trial.		Four-hours' coal consumption.		
							Indicated horsepower.	Speed.	Indicated horsepower.	Speed.	Coal per I.H.P. per hour.
		ft.	*tons.*		*sq. ft.*	*sq. ft.*		*knots.*		*knots.*	*lbs.*
Cherwell.....	Palmers	225	550	Reed	15,514	319	7,250	25.603	7,207	25.38	2.34
Dee.....	Ditto	225	550	Ditto	15,514	319	7,306	25.504	7,206	25.413	2.28
Derwent.....	Hawthorn	220	550	Modified Yarrow	14,852	277	7,241	25.68	7,580	25.295	2.24
Waveney.....	Ditto	220	550	Ditto	14,852	277	7,307	25.626	7,574	25.356	2.19
Ribble.....	Yarrow	225	590	Yarrow	16,000	270	7,417	25.817	7,668	25.33	1.572
Welland.....	Ditto	225	590	Ditto	16,000	270	7,777	26.24	7,720	25.35	1.654
Kennett.....	Thornycroft	220	550	Thornycroft-Schulz	16,160	268	7,445	25.665	7,543	25.99	2.395
Jed.....	Ditto	220	550	Ditto	16,160	268	7,990	25.787	7,425	25.39	2.464
Eden.....	Hawthorn—hull / Parsons—turbine	220	550	Modified Yarrow	14,852	276	...	26.229	...	25.287	...
114.....	White	165	200	White-Forster	6,218	109.9	3,034	25.154	2,969	24.803	2.15
115.....	Ditto	165	200	Ditto	6,218	109.9	3,047	25.187	3,011	24.835	1.97
116.....	Ditto	165	200	Ditto	6,218	109.9	3,001	25.22	2,999	24.878	1.95
117.....	Ditto	165	200	Ditto	6,218	109.9	3,016	25.115	2,975	24.779	2

The nine torpedo-boat destroyers tried during the year belong to the 25½-knot class, regarding the design of which craft doubts have been expressed, because, although much stronger and having a wider radius of action, the reduction in speed is viewed as serious by many naval strategists. Ten of these vessels were tried in the previous year, so that nineteen have now been added to the fleet, and several still remain to be completed. The results embodied in the table are fairly uniform, although the range in power is considerable. The practice in these vessels is to make first an endurance trial, the coal consumption on which determines the load to be carried at full power. This in part may account in some cases for the higher power required on the full-speed run. The results of the trials of the vessels built by Messrs. Palmers are notably successful in respect of propulsive efficiency. During the past two years 25½ knots have been realized by five of their vessels with powers ranging between 6,957 and 7,306 indicated horsepower. Messrs. Hawthorne, Leslie's vessels on Table II show similarly good results. The Yarrow boiler in the Yarrow boats has given very economical results; and although in the case of the *Welland* the power is 500 indicated horsepower higher than in some of the other ships, the speed is better by from .6 to .75 of a mile. One of the destroyers included in the list—the *Eden*—is fitted with turbine machinery; but there is no no means here of accurately determining the power required.

The miles run at full speed per ton of coal number about the same as those for the same design of vessel with the same type of boiler, but fitted with reciprocating machinery, *i. e.*, 3.4 miles per ton. At low power the results with the turbine are not so satisfactory. These comparative results, however, are not conclusive, and further trials are being made. Meanwhile the Admiralty are arranging for the building of 32 and and 33-knot destroyers, and it seems probable that, at least at full speed, better results will be achieved with the turbine as a propelling agent than with reciprocating engines; but a

method has yet to be devised whereby a good economy can be got at low power.

The four torpedo boats on the list resemble the type added to the Navy from time to time to maintain the number of this craft at their present standard. These vessels are of 25-knots speed, and in all cases this rate has been exceeded with the legend power. The Admiralty are at the present time inviting tenders for the construction of five more vessels of the same class.—" Engineering," London.

SHIP BUILDING.

From the returns just issued by Lloyd's Register for the quarter ending December 31, 1904, we see that there is (excluding warships) an increase in the tonnage of vessels now under construction in the United Kingdom. This increase amounts to 151,382 tons over the returns for the corresponding quarter of 1903, the figures being 1,049,860 tons for 1904 against 898,478 tons for 1903. The tonnage belonging to the quarter just ended are accounted for by 403 vessels, against 386 in the corresponding quarter of 1903. At the end of September last there were building 393 vessels, totaling 1,046,308 tons, so that the figures for the quarter just ended and those for the previous one are very nearly alike. Of the total number of vessels now in hand, 371 are for steam and 32 for sail. The present figures, however, when compared with the record total reached in September, 1901, show a reduction of about 363,000 tons. Of the vessels now under construction, the surveyors of Lloyd's Register have 315 under their supervision, the tonnage of which is 748,177; but, in addition to these, 43 vessels, of 110,763 tons, are being built abroad, with a view to classification in the society. The total now building under the supervision of Lloyd's Register is, therefore, 358 vessels, of 858,940 tons. During the quarter ending December 31, 1904, there were 177 steamships commenced, having a gross tonnage of 329,457, together with

eight sailing vessels, with a gross tonnage of 1,350. Of vessels previously commenced, but on which no further progress has been made, there are fifteen steamships, with a tonnage of 85,488, and six sailing ships, with a gross tonnage of 914.

TABLE XV.—TONNAGE OF SHIPS LAUNCHED (INCLUDING WARSHIPS) IN EACH MARITIME COUNTRY.

.....	1901.	1902.	1903.	1904.
Austria-Hungary	27,413	23,361	28,848	28,125
Belgium	5,631	14,946	12,804	6,686
China	3,694	3,400	2,364	709
Denmark	26,056	27,148	32,059	15,859
France	232,404	236,635	123,528	124,845
Germany	284,063	257,885	245,084	247,167
Holland	35,856	73,973	59,594	61,404
Italy	88,329	62,288	57,389	58,678
Japan	37,208	36,481	41,004	33.577
Norway	36,875	37,878	41,599	50,469
Russia	39,890	52,579	45,404	8,143
Sweden	19,191	9,030	15,505	10,375
Other European countries	2,496	5,507	3,669	3,436
United States	481,138	396,433	450,090	409,403
Other countries	...	...	592	763
Colonies	28,134	28,819	34,690	30,965
Total foreign and colonial,	1,348,378	1,266,363	1,194,223	1,090,604
United Kingdom	1,736,708	1,521,698	1,342,508	1,332,337
Total for world	3,085,086	2,788,061	2,536,731	2,422,941

TABLE XVI.—THE NUMBER AND TONNAGE OF WARSHIPS LAUNCHED, 1892-1904.

.....	British.		Foreign.	
	No	*tons.*	*No.*	*tons.*
1892	30	151,157	53	157,744
1893	18	45,898	33	133,635
1894	31	32,971	27	87,050
1895	59	148,111	23	100,614
1896	55	163,958	37	167,833
1897	48	95,465	42	133,435
1898	41	191,555	50	175,318
1899	35	168,590	56	176,170
1900	29	88,364	70	192,100
1901	41	211,969	82	255,578
1902	23	94,140	80	191,166
1903	41	151,890	78	239,210
1904	37	127,175	65	307,831

TABLE XVII.—TABLE SHOWING THE NUMBER AND TONNAGE OF VESSELS OF 100 TONS GROSS AND UPWARDS (EXCLUDING WARSHIPS) LAUNCHED IN THE PRINCIPAL COUNTRIES.

Year.	United Kingdom.	Austria-Hungary.	British Colonies.	Denmark.	France.	Germany.	Holland.	Italy.	Japan.	Norway.	United States.	Other countries.	Totals.	
	tons.	*tons.*	*tons.*	*tons.*	*tons.*	*tons.*	*tons.*	*tons.*	*tons.*	*tons.*	*tons.*	*tons.*	*No.*	*tons.*
1892	1,109,950	2,302	19,792	12,707	17,228	64,888	14,368	13,888	...	24,572	62,588	15,762	1,051	1,358,045
1893	836,383	7,435	17,089	10,719	20,337	60,167	1,339	10,626	1,132	16,552	27,174	17,788	846	1,026,741
1894	1,046,508	1,703	6,803	7,300	19,636	119,702	15,360	5,396	3,173	17,169	66,894	13,894	932	1,323,538
1895	950,967	7,371	10,381	10,982	28,851	87,786	8,292	5,603	2,296	12,873	84,877	7,881	880	1,218,160
1896	1,159,751	6,246	11,124	11,814	44,565	103,295	12,405	6,779	7,849	12,059	184,175	7,820	1,113	1,567,882
1897	952,486	6,601	12,431	13,539	49,341	139,728	20,351	12,910	6,740	17,248	86,838	13,711	990	1,331,924
1898	1,367,570	5,432	25,021	12,703	67,160	153,147	19,468	26,530	11,424	22,670	173,250	8,968	1,290	1,893,343
1899	1,416,791	9,248	8,464	26,613	89,794	211,684	34,384	49,472	6,775	27,853	224,278	16,382	1,269	2,121,738
1900	1,442,471	14,889	9,563	11,060	116,858	204,731	45,074	67,522	4,543	32,751	333,527	21,174	1,364	2,304,163
1901	1,524,739	20,013	28,134	22,856	177,543	217,593	29,927	60,526	37,208	36,875	433,235	28,890	1,538	2,617,539
1902	1,427,558	15,192	28,819	27,148	192,196	213,961	69,101	46,270	27,181	37,878	379,174	38,277	1,650	2,502,755
1903	1,190,618	11,328	34,690	28,609	92,768	184,494	59,174	50,089	34,514	41,599	381,820	35,928	1,650	2,145,631
1904	1,205,162	16,645	30,965	15,859	81,245	202,197	55,636	30,016	32,969	50,469	238,518	28,254	1,643	1,987,935

The number of vessels launched during the quarter was 160 for steam, and seventeen for sail. Of the number now building, 282 steamships and 25 sailing vessels will be under the British flag, being intended for the United Kingdom or the Colonies, and represent a tonnage of 834,427. Germany takes three steamships of large size, representing 34,450 tons; Norway nine, representing 33,147 tons; Holland four, representing 19,460 tons; Austria-Hungary five, representing 18,270 tons; and Denmark five, representing 10,185 tons.

Among the vessels now under construction are five, each having a tonnage of over 15,000, and three of from 10,000 to 11,999 tons each. Of war vessels now building, there are eight under construction at the Royal Dockyards and 46 in the yards of private firms. Of the former, four are first-class battleships, having a total displacement of 65,400 tons; three are first-class armored cruisers, having a displacement of 37,950 tons; and one is a second-class protected cruiser, with a displacement of 5,800 tons. Of those in hand at private yards, nine are first-class armored cruisers, eight are scouts, sixteen are torpedo-boat destroyers, and ten are submarine boats. These are all for the British Government; while, in addition, two battleships and one torpedo-boat destroyer are being constructed by private firms for foreign countries. This makes a total of 54 war vessels in all, with a total displacement of 282,810 tons. Two of the battleships are under construction at Portsmouth, one at Chatham, and one at Devonport. One of the first-class armored cruisers is being built at Chatham, and two at Pembroke; while one second-class protected cruiser is in hand at Devonport. The work at the private yards is divided between Barrow, Blackwall, Clydebank, Elswick, Govan, Greenock, Birkenhead, Chiswick, Cowes, Hebburn, Jarow and Poplar.

In connection with the above, which is from "Engineering," London, the tables on pages 140–141 taken from Lloyd's Register are of interest.

TRIPLE-SCREW PROPULSION.

By REAR ADMIRAL GEORGE W. MELVILLE, U. S. N., Retired, in "Marine Engineering".

The lessons of the war in the far east are more than interesting to the engineering profession, particularly so to that which relates to ship construction and marine engineering.

The order of our President is explicit, that no officer of the Army or Navy of the United States shall enter into any discussion of the relative merits of either nation or course of action of either their fleets or armies. It is not only just that the President should issue such an order, but that the order should be implicitly obeyed. But this does not bar us from learning lessons for ourselves that may be applied to the benefit of our Navy in our new constructions. The first lesson we have learned is the necessity for a high-powered fleet of fast ships, either battleships or armored cruisers, with great coal endurance and perfect protection to the propelling power and steering gear of this class of ships.

The lesson of the loss of the *Rurick*, the Russian armor-clad ship, the consequent delay and scattering of the Russian fleet at that time, the forced return of some of the ships of that fleet to Port Arthur, and subsequent abortive attempt to join Russia's Vladivostock and Port Arthur fleets into one strong fighting unit, may be traced to the fact that the *Rurick's* steering gear or rudder and part of her propelling power were disabled at the same time.

As the report comes to us, it is said that a shell from one of the Japanese ships exploded under the stern of the *Rurick*, disabling her rudder or steering gear, and at the same time disabling one of her twin screws. Now, had this ship been a three-screw ship, as nearly all of Russia's modern ships are now fitted, as well as those of Germany and France, it can readily be seen that had her center screw and one of her wing screws remained intact, the ship could have proceeded with at least two-thirds power, and in an emergency even greater power could have been crowded through the two remaining engines and screws, so that not only the *Rurick* might have escaped,

but possibly the whole fleet. As it was, because of the delay of more than one hour, when the Russian fleet was trying to blanket and protect the damaged ship, the time thus lost, if skillfully used, even in a running fight, might have saved the fleet to Russia. Whether this reasoning would apply in all cases and under all conditions is a question that is is impossible to decide off-hand, for so many contingencies arise in battle that no fixed rule can be made to fit them all.

Accompanying this prelude to my subject, I take pleasure in stating the following reasons why the three-screw system should be applied to naval vessels of more than 3,000 tons, bearing in mind that it is not a new or novel system, but that it is in almost universal use in the navies of Russia, Germany and France; Great Britain and the United States alone neglecting this great military advantage in time of war and the greatest source of economy in coal in time of peace or on blockade.

Not only for men-of-war alone, but for the high-powered transatlantic liners, the three-screw system would prove most advantageous in case of accident to either engine or rudder, and as the increase of engineer force in engine or fire rooms amounts to but six per cent. of the number of men, it is a small amount to pay for the increased security in mail-passenger service.

In the United States protected cruisers *Columbia* and *Minneapolis* the additional force employed for each ship in the engine room, for oilers, was but nine men, or three on each watch for three watches when the ship was under way. Now that we are having numerous three-screwed turbine ships projected and being built, and many more projected with four shafts and propellers, three-screwed ships will cease to be a novelty, and the traveling public on our high-powered transatlantic liners will demand the three-screw system as they now do the twin-screw, and avoid a single-screw ship. After years of service, the machinery of the *Columbia* and *Minneapolis* is reported in as good condition as when built, and the fleet engineer of the training squadron reports to the Navy

Department that the ships are able to make the speed they did on their trial trips, which speaks well for their design, builders, and the care and attention they have had from the engineer force since they were first commissioned. In fact, the adoption of the three-screw system for ship propulsion will act as rudder and propeller if rudder or steering gear and any one of the three screws or engines is disabled.

The following are a few of the reasons in favor of the three-screw system. I have also stated some of the disadvantages that might arise from the system:

The triple screw is no novelty in naval construction. It has been used in Russia, France and Germany. Russia possesses eleven naval ships fitted with triple-screw engines, and these ships are of late design. France has ten battleships and nineteen cruisers of this type, and the latest armored cruiser launched, *Dupetit-Thouars*, is fitted with triple screws. In the case of Germany, the decision has been practically reached, after competitive trial of the twin and triple-screw systems, to adopt the triple-screw design exclusively in all future warships of the home fleet. She has already nineteen such vessels.

England alone, of the strong naval powers, continues to design twin screws for her most powerful vessels. In doing this she is only pursuing that same conservative policy which makes her refuse to drive her turrets electrically, and which impels her to shun superimposed gun turrets. If this conservatism upon the part of England, as respects the question of triple screws, is based upon sound engineering design, then what reason have we for maintaining that the British Admiralty is not equally justified in its decision to adhere to the hydraulic working of turrets, and in its determination to reject, for all classes of ships, the superimposed arrangement for heavy guns. Concerning the conservatism of the British Admiralty "Marine Rundschau," a leading German periodical, in its issue of March, 1901, says:

"It must be pointed out how inordinately conservative they (the English) are for holding on to old methods, and how they object to anything new in their navy. It was only after the

French had built ironclads, and had successfully tried them, that the English decided to change their 'wooden walls' to iron ones; and they were many years behind other navies in adopting breech-loading rifles."

In matters pertaining to the naval personnel, it has been the practice of Great Britain to follow rather than to lead our service. In matters pertaining to the material she has always assumed the conservative attitude, maintaining the position that as the greatest sea power she could rest well content with existing conditions, and that such construction as submarine and commerce destroyers are the expedients of weaker powers. Therefore, with respect to the best distribution of motive power, as well as with respect to the question of the arrangement and distribution of battery, the British Admiralty is regarded rather as observers than opponents of American precedents.

In adopting the triple-screw system there will not be introduced either any innovation or discredited design of motive power. The demand for this character of installation is made rather to prevent us falling behind our competitors in naval construction than in the desire to lead our rivals. The practical reasons for thus distributing the power in armored vessels may be embraced in three distinctive groups.

ECONOMIC ADVANTAGES.

Where judgment has been exercised in utilizing the power, marked economy has been secured by the use of triple screws. The economy of this installation is so well recognized by the Germans that the matter is no longer in dispute. It would be remarkable if there were not economic advantages. There must be a saving of coal where the distribution of power is of such nature that only the amount of machinery need be put in operation which can be run at economical speed.

The official trials of the *Columbia* and *Minneapolis*, when compared with those of the *New York* and *Olympia*, prove conclusively that there was a decided economy of propulsion. Probably no data were ever obtained with more care than in the official trials of the four ships named. There was an ample

corps of trained observers. The system of observations was the result of experience after many official trials. The indicators had been most carefully calibrated by the same experts in all cases, and the apparent pressures were corrected for the errors of the instrument. There can be absolutely no doubt of the accuracy of the data.

Some of the special economical advantages are the following:

(1) In time of war, or emergency, the ordinary cruising can be maintained by the side engines, while the center engine is run at just sufficient speed to clear its propeller. Where there is a necessity for an economical expenditure of coal and an equal necessity for being in readiness to move quickly, the center engine can be run slowly while the side engines can just turn over. In either of the above cases the load on the engine that is just turning over is only that due to friction, and therefore the coal expenditure is exceedingly small. Such operation of triple-screw engines was actually done on the *Minneapolis* during the late war. When operating the engines in this manner it is only necessary to open all the throttles to secure a maximum speed. Such a condition or readiness, at a slight cost of fuel, can only be secured with triple screws.

(2) At full power the economy will be equal to or greater than with twin screws. At reduced speeds the economy will be much greater, thus increasing the steaming radius and keeping the vessel longer on blockade or other important duty.

(3) The economy is secured by more efficient propulsion. It is also attained by the more efficient use of steam in the engine, due to decreased condensation following the increased piston speed.

(4) The economy of the triple-screw system has been shown by actual experiments and experiences in our service. These results have been verified by the experience of the French and the Germans. Russia has not conducted comparative tests, but the general belief exists in that service that the triple-screw system is the most economical.

The economic superiority of the triple-screw design is now practically recognized by every nation that has possessed

ships of the two types. Such judgment has been founded upon experience and experiments. A design of motive power which secured a reduction in the consumption of coal is of great military advantage. "Coal, or the want of it, is the life or death of a fleet." Its consumption must be reduced on the modern war ship, and the great trend of marine engineering research is in the direction of such economy. To continue building twin-screw engines in high-powered naval vessels is to be one engine behind in the race for naval supremacy.

STRUCTURAL ADVANTAGES.

In addition to the economic advantages resulting from the design, there are structural reasons why the system should be adopted. The following are a few of the resulting advantages:

(1) The engines can be made lighter, cheaper and simpler.

(2) The subdivision of watertight compartments is more efficiently secured.

(3) The nearer the screw to the center of the vessel the more efficient it is. The screw need not extend so far beyond the lines of the hull. The screw is less liable to disablement from ramming any floating obstructions.

(4) Shorter lengths of shafting can be used. The use of struts can be obviated under certain conditions.

(5) Smaller engine parts can be used. This is a marked military advantage, since it will not only reduce the cost of repairs, but permit the repairs to be made more rapidly as well as by a greater number of engine repair shops.

(6) The vibration is decreased. This advantage is of great importance, since it not only adds to the endurance and efficiency of the machinery, but contributes to the comfort of the crew, and passengers, if a passenger ship.

(7) Triple screws permit the installation of additional auxiliaries. The auxiliaries are the weak links in a modern battleship, and by the disablement of a single one a set of propelling engine can be thrown out of use. Where three sets of auxiliaries are installed, it would be but seldom that two sets of engines could not be kept in operation. In fact, two

auxiliaries of any one description could be so forced that it might not be necessary to stop working any of the propelling engines if an auxiliary was disabled.

(8) More latitude is allowable in the design of machinery. Smaller and more efficient propellers can be designed, the piston speed increased, the foundations made lighter, the working parts smaller, and all permit greater ease of repairs.

Structural reasons first impelled the marine engine designer to suggest the triple-screw engines. The advantages were so apparent that the installation was secured. The resulting structural and engineering benefits were very great, and yet it is but fair to recount the disadvantages which the system entails.

The following are the principal structural disadvantages:

(a) Greater number of parts. In all high-powered naval vessels fitted with twin screws there are two sets of engines coupled on to each shaft. Six cylinders with their attendant working parts are required for each set of machinery, so that as a matter of fact there are more working parts with the twin-screw system of the same power.

(b) Greater number of valves and pipes; but these fittings are smaller, and therefore more easily overhauled and repaired.

(c) Greater number of auxiliaries. In the cross security of being able to use any auxiliary on any propelling engine this ought to be a marked advantage.

(d) Increased engine-room force. The total increase in the fire and engine-room force is about six per cent.

(e) Intricacy of piping. Additional piping, of course, is required, but no man competent to run high-powered machinery would regard the additional lengths of piping as producing complication, and in all cases the piping is smaller in proportion to the unit used.

(f) The engine space requires more room lengthwise. Space is utilized in the afterpart of the vessel, however, that could be only used as store rooms for spare gear.

The structural advantages so far exceed the disadvantages that from an engineering standpoint there can be no justifica-

tion henceforth for the use of twin screws in large-powered vessels. It must be understood that by the adoption of the triple-screw system we use three sets of engines instead of four. The *New York* and the *Brooklyn* have two sets of engines coupled to each of the twin-screw shafts for economy in fuel at low cruising speed. The experience of the *Brooklyn* at Santiago shows that where two sets of engines are coupled to the same shaft, the vessel would practically go out of action if the attempt were made to couple the shafts in times of emergency. These are sufficient structural reasons alone to justify the adoption of the system.

TACTICAL ADVANTAGES.

In addition to the economical and structural reasons for installing triple screws there are tactical advantages to be secured. When the German Admiralty began giving consideration to this subject her experts did not look for other than economical and structural advantages. In fact, it was believed that investigation would show that tactical reasons would prevent the further use of triple screws in German warships. With the thoroughness that characterizes German research, extended experiments were planned for the determination of this question. The *Friedrich III*, fitted with triple screws, was pitted against the twin-screw ships *Brandenburg* and *Sachsen*. All manner of tactical evolutions were attempted. To the surprise of the German experts the *Friedrich III*, fitted with triple screws, showed a marked tactical superiority over her rivals.

These experiments caused increased attention to be given to the tactical reasons for adopting the triple-screw system. It was found that the ships fitted with such installations steered best, and that the art of steering was more easily acquired by the sailors, as the ships took no rank sheer, as is found to be the case with vessels carrying twin or single screws.

As confirmatory of the *Friedrich III-Sachsen* experiments, the following particulars are given: The first squadron of

German battleships, comprising three vessels of the *Imperial* type—*Emperor William the Great*, *Emperor William the Second*, and *Emperor Barbarossa*—fitted with triple screws, made two long cruises during the past summer. It is reported of them that they could be more easily steered and maneuvered, a new proof of the advantages of the triple screw over the double propelling system of the *Brandenburg* type.

The remarkable fact is now presented of the German experts declaring that it is principally for tactical reasons, and not by reason of the structural and economical advantages, that Germany has settled upon the policy of using triple screws for all large-powered ships in home waters. The following are the principal tactical advantages:

(1) Increased assurance of working the entire machinery. This is of special importance in battle or in time of emergency, when maximum power is required for a short period. At Santiago the *Brooklyn* could not use her maximum power because only the after engines of each shaft could be used, the forward engines being uncoupled.

(2) Decreased liability of imperiling the motive and maneuvering power of the vessel. This advantage arises from being able to install the screws near the center of the vessel, thus decreasing the chances of the propellers being hit by a floating obstruction.

(3) The steering or maneuvering qualities of the ship are not so likely to be interfered with in triple as in double screws, since it is not likely that more than one engine will be disabled, as in the case of the Russian battleship *Rurick*.

(4) A tactical advantage, not hitherto shown, is better control when under stern board. An experiment with the *Columbia* when in a narrow channel went to show that she could readily be steered when going astern by carefully handling the engines and disregarding the helm, the helm being amidships. This we know cannot be done with either single or twin-screw vessels.

(5) A helm angle from 6½ to 10 degrees is required to keep

a twin screw on her course when only one screw is used. No such angle would be required when one of the three screws is disabled.

(6) Greater safety of machinery due to better distribution of power.

(7) In case the rudder is carried away or disabled the triple-screw ship can be more easily handled, since the wing screws can be used for guiding and the center one for propelling the vessel—again the *Rurick*.

(8) All the tactical advantages secured by twin-screw vessels are maintained; additional ones are attainable.

The *Brandenburg-Sachsen* experiment showed that evolutions could be performed with triple screws that could not be done with twin screws. The March number of the "Marine Rundshau" gives detailed description of buoy experiments which could only be performed by ships fitted with triple screws.

Since the triple-screw design permits smaller engines to be used, there is a tactical and military advantage in such construction. Smaller engines are cheaper, lighter, simpler, more easily managed and more easily overhauled. This may be of great significance, now that we are finding such difficulty in securing trained men for the engine rooms of our warships. In view, therefore, of the economical advantages, as shown upon official trials; of structural advantages, as recognized by marine engineers, designers and builders, and of tactical advantages, as determined by careful experimental investigation and research, there should be no hesitancy in using the system.

The distribution of the motive power is no less important than the distribution and arrangement of the battery. It is just as logical to arrange the battery of the new warships in the same manner as was done a decade ago as it is to continue the custom of installing a twin-screw arrangement of motive power that is not in accord with existing needs.

For the past five years I have continuously and consistently urged the installation of triple screws for high-powered ships. My only regret now is that I was not more insistent in urging

the adoption of the system. Under several occasions I determined to present a minority report against twin-screw engine propulsion for high-powered ships. Such official protests were not made because the assurance was given that there were grave tactical objections to its introduction, and that data to support the contention would be furnished. With each succeeding year progressive evidence has been adduced that the system is not only in accordance with sound engineering practice, but it supplies a tactical need of the future battleship.

The triple-screw system for high-powered naval vessels is no longer either an innovation or an experiment—it is a military necessity. The continued installation of twin screws in such vessels is not only against progressive engine design, but fails to meet the military and tactical requirements of the future. If such practice continues our naval prestige will be lessened. To defer adopting triple screws is marked retrogression. The distribution of power by triple screws is simply keeping pace with the best naval construction of Europe. Any action of a contrary nature is simply discrediting the ships in process of design. It is, therefore, imperative that this system be adopted unless the facts herein set forth can be controverted.

SUPREMACY OF THE BATTLESHIP.

That the impression which has gained credence in some quarters to the effect that the efficiency of the battleship has been discounted by the operations in the far Eastern war may be corrected, the Navy Department has issued the following official statement commenting upon the naval operations of the Russian and Japanese fleets and calling attention to the fact that absolute supremacy of the battleship has throughout the war been again and again demonstrated. The statement was prepared by a member of the General Board who is well known as a tactical and strategical expert and represents the views of the Board and of the Secretary of the Navy. It follows:

"The present war in the far East has in its many-sidedness

given pause to many whose vocation and tastes lead them to ponder questions of military policy and strategy. The conduct of the Japanese armies has won world-wide admiration, equalled only perhaps by that aroused by the heroic resistance of the Russian garrison at Port Arthur.

"A still greater surprise, perhaps, has been caused by the superb condition and efficiency of the Japanese fleet, ascendancy upon the seas being supposedly a less natural development of their old-time war spirit than a fighting supremacy on shore. Every type of war vessel has its place in the navy of that country, and it is not too much to say that each has been used in the manner and for the purpose to which it is best adapted and for which it was intended; and perhaps no more useful book is opened to the modern tactician than a thorough and logical study of the employment of the different weapons. In such a study sound conclusions may differ surprisingly from hasty conceptions.

"To neutralize something powerful and costly by means of an inferior and cheap agent has always been an attractive theme; but seldom, if ever, have the ends attained justified the brilliant expectations of those who have allowed their imaginations to run riot. In 1805, William Pitt, upon examining the plans of Fulton's torpedo boat, remarked that if that mode of fighting were adopted it would be the end of military navies; and yet a hundred years have passed and the battleship still stands supreme. During these generations the French, despairing of opposing equal force to the British fleets, had adopted the policy of employing swift cruisers for commerce destroying, and they actually did capture a great many merchant ships of their hereditary enemy; but the injury was confined to the feelings of the many and the pockets of the few; supremacy on the sea and mastery of the situation remained with the nation whose naval line-of-battle stood unbroken. In the early days of the modern development of the torpedo boat, the fascinating idea again came to the front of using those vicious little craft to annihilate fleets; the imaginary contest was likened to that of the microbe attacking the

elephant; but the revulsion has not come; experience gradually caused it to be seen that the laws of nature remain the same, and that a small and frail cockleshell cannot maintain either speed or even existence at sea in the same manner as a heavy ship; the results of the present war in the East appear to demonstrate that not only is the availability of a torpedo boat at the front dependent upon having a supporting ship and convenient base and refuge, but that prospect of success is greatly enhanced by the presence of a containing force to restrain the enemy and keep him in a situation favorable to the attack. It has been suggested that even the dormant mine has in this war been so successful as to almost enter the category of *offensive* weapons and thus still farther discountenance the battleship; in its important, though somewhat accidental results, the mine may be likened to a small chemical pellet which will surely prostrate the strongest man in his carelessness, but which can surely not do a man's work in the world.

"Ships must not touch mines, and must protect themselves against the torpedo, but their power in bringing war to a successful issue never has been stayed, except by a greater force of a similar nature. And an examination of the results of the various modes of attack brings out the additional evidence of this war as indicating the probable immutability of that governing principle.

"In the brusque inauguration of hostilities by the Japanese torpedo-boat flotilla at Port Arthur, during the night of February 9, they did undoubtedly deliver a telling blow by disabling three Russian battleships. The temporary crippling of that force affected the conduct of operations, not only during the beginning, but throughout the entire first phase of the war; the Japanese, having by that stroke won the mastery of the sea, were able to land troops at the Yalu and later at Niuchwang, instead at the far south end of the Korean Peninsula. This mastery was due to their having the preponderating force of battleships, which alone enabled them to blockade the Russian fleet. No more eloquent tribute to the pre-eminent value

of battleships is to be found than this one circumstance, that the small margin of superiority thus obtained saved the army hundreds of miles of precarious and weary land transport of men and supplies, enabling them to strike swiftly, hard and continuously upon a weaker enemy before he could be reinforced.

"On the other hand if, under normal conditions, battleships can be destroyed or seriously damaged by unsupported torpedo boats their value is seriously compromised. This, however, does not appear to be the case. The action of February 9 was a surprise far excelling the usual elements of a surprise attack; the Russian fleet, fourteen vessels in all, were anchored close together in the outer funnel-shaped roadstead, without suspicion of impending hostilities, not a patrol boat being out, and the crews peacefully sleeping in their usual berths; three Japanese destroyer flotillas (twelve vessels) approached with lights burning, and being mistaken (as intended) for Russian boats returning, were allowed to approach close to the huddled fleet; then, with a smooth sea, at close range, hardly disturbed by a single shot in return or flash of searchlight, with all the conditions of easy target practice, not less than twenty-four torpedoes (and probably more) were discharged, of which three took effect. The results were undoubtedly momentous; but it would be a hardy logician who could deduce from that incident the comforting thought that the little torpedo craft has displaced the battleship or even materially diminished its prestige. As is well known to all who have followed in the press the procession of events, Admiral Togo's fleet left Japan at the time the message was sent recalling the Minister at St. Petersburg, established a naval base in the islands neighboring to Port Arthur, and thenceforth, with his battleships and large cruisers, invested that port and supported his small craft in their constant attacks; protected from torpedo attack by his own torpedo flotillas, he blockaded the Russian fleet and immobilized their battleships. Although the Russian destroyers in Port Arthur numbered

twenty-four, or eight more than all in the U. S. Navy, not one has scored a hit so far during the war.

"Scores of other torpedo attacks have been delivered by the Japanese, but nearly all met with complete lack of success, although made, as usual, under the cover of darkness and against an enemy at anchor and whose position was known. Opon one occasion, after a soul-stirring night, that of June 23, the Russian ships being in the outer roadstead, twelve torpedoes were picked up in the morning, having missed their marks and having their mechanism apparently set to float at the end of the run (instead of to sink, as is customary), in the evident hope that they might find a target while drifting about. How many others were sped during that strenuous night, and sank or drifted away in the tide, will probably never be known. In a few other cases hits were scored which laid the victims up for a few days, after which they returned to service. But the fact remains that not a Russian has been sunk by a torpedo until just recently, when the *Sevastopol* succumbed to the incessant attacks, she being 'contained' by the Japanese battle fleet and compelled to lie helplessly anchored ouside of the harbor, entirely exposed, and with many of her guns landed to aid in the shore defenses. The circumstances were indeed peculiar. The fleet in Port Arthur had been destroyed by gun fire, the Japanese having occupied a hill which allowed them to deliver a direct fire on it with siege and naval guns. The *Sevastopol* was moved to the outer roadstead, and, hemmed in by Togo's battleships, anchored under the Tiger's Tail forts, protecting herself by a boom defense and nets of other vessels lost. This defense withstood continuous night attacks by Japanese destroyers and torpedo boats for ten days, when she was finally struck by three torpedoes, and is now beached on the rocks under Golden Hill forts. She was a stationary target day and night for two weeks, and it is not known how many attacks were delivered against her, but a probably low estimate of the number of torpedoes fired would be 150. The Japanese suffered severely in the attacks, and lost two destroyers and some of the smaller torpedo boats. The weather, while severe

upon the boats' crews, was evidently favorable for torpedo work, as the reports refer to snow, rain, sleet and the elements generally being bad.

"Day attacks by torpedo-boats have never been regarded as worth attempting. Several incidents of this war have been illustrative of their impotence in daylight. The first was when the *Variag* came out of Chemulpo to face the Japanese squadron; not a single torpedo-boat was permitted to enter the field of action. Again, during and following the fleet action of August 10, although there were present eight Russian destroyers and at least fifteen Japanese destroyers and many torpedo-boats, not a torpedo reached its mark, if, indeed, any were discharged; none dared to approach within torpedo range by daylight. The same is true of the action of August 14, between the Vladivostok armored cruisers and Admiral Kamimura's fleet; the ill-fated *Rurik* was crushed by gun fire alone, and the torpedo-boats effected nothing against the *Rossia* and *Gromoboi*, which escaped to Vladivostok, although badly damaged by gun fire. So far as actions on the open sea are concerned, it may be said that in none have the results been influenced in any way by the presence of the torpedo-boat or the torpedo-boat destroyer.

"Somewhat to the chagrin of students of the game of naval warfare, this war has afforded no field for the discussion of cruisers. The armored cruisers of the two fleets have simply been mutually pitted one against the other; 'protected' cruisers, whose whole sphere in military operations has of late years been admitted to be restricted to extended sea-scouting, have been barred from that service by the localized character of the operations, the smaller craft, with their wireless telegraph systems, being on constant sentry duty off Port Arthur and notifying Admiral Togo of any threatened sortie. Vessels of all types were present in both fleet actions, but the attention of both sides appears to have been devoted exclusively to crippling each other's battleships. Nor have there been any individual actions between unarmored ships, other than the destruction of the gallant little *Novik* by the *Chitose* and *Tsus-*

hima. The *Variag*, upon issuing from Chemulpo, was, of course, immediately crushed by the overwhelming force confronting her. The other Russian cruisers were of occasional assistance in driving off the enemy's torpedo boats or rescuing their own; but rarely has the name of any such vessel caused occasion for mention in either official or press reports.

"The overshadowing importance of the battleship is nowhere more appreciated than in Japan. Had they had at the outset twelve, or even ten, battleships instead of six, the Russian fleet would have been destroyed on August 10—the supreme incentive to holding out at Port Arthur being thus removed, that fortress would probably have fallen, the war correspondingly advanced and thousands of lives and millions of treasure saved. Threatened now by the Russian second Pacific fleet, it is safe to say that they would gladly recover at several times their cost the *Hatsuse* and the *Yashima* (if so be it that the uncontradicted reports of the latter's loss be true); for well do they know that the loss of the command of the sea would mean the end of the campaign in Manchuria. Likewise gladly would the Russians buy back the *Petropavlosk*, sunk in the same manner as the two Japanese—by mines skilfully planted by the enemy.

"In summing up the lessons of the war one cannot do so more accurately or felicitously than was done by Lord Selborne, First Lord of the British Admiralty, in the following words:

"'The lessons from the war in the Far East are the importance of the personnel, the necessity for having a margin of strength, and the fact that without battleships no power can hold or win command of the sea.'"—"Army and Navy Journal."

THE BEST ECONOMY OF THE PISTON STEAM ENGINE AT THE ADVENT OF THE STEAM TURBINE.*

By PROFESSOR J. E. DENTON, M. E.

When James Watt retired from business, at the beginning of the nineteenth century, he had declared his belief, based on

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theoretical calculations, that the water consumption of a steam engine per horsepower decreased with the increase of the ratio of expansion until the pressure of release should be equal to the exhaust pressure. But, although Watt invented a valve gear with which to test his theory, he never worked steam expansively to any practical degree in any of the engines built by him, because the demand for them simply as multipliers of the power available from other prime movers of that day was at too great a premium to make it necessary for the firm of Boulton & Watt to improve the economy of their engine by the application of the principle of expansion.

As builders of steam engines multiplied, however, economy became the ruling factor of competition, and the principle of expansion was applied in the pumping engines of Cornwall, with increasing economy, up to the greatest ratio of expansion consistent with commercial limits of size of cylinder per horsepower. Hence, when in 1840 one of the leading Cornish pumps was reliably tested for water consumption at ratios of expansion varying from 1.5 to 3.5, with results showing from 24 to 16.5 pounds of steam per horsepower hour, and it was found that these figures agreed with Watt's theory, belief in the latter was practically universal, and expansion was relied upon to yield similar results, in all important engines of land and sea, up to 1855.

The engineers of this time failed to realize, however, that the Cornish pump, with its single action and equilibrium exhaust, never exposed the working end of its cylinder to the temperature of the condenser, so that the range of temperature to which the admission end of the cylinder was exposed was only a fraction of that undergone by the steam, a fact which realized the conditions of action of a compound engine. They also failed to realize that the steam was superheated during admission by excessive wiredrawing from the boiler pressure of 45 pounds to 18 pounds absolute, and further, that a live-steam jacket heated the cylinder walls to initial temperature during a very slow indoor stroke, while admission occurred during the very quick outdoor stroke.

These facts made it possible for the Cornish pump to act without cylinder condensation—a phenomenon which Watt's theory did not recognize to exist; so that it was consistent that his theory should completely account for the performance of this engine as determined by experiment. But the ordinary double-acting non-jacketed engines of the marine and stationary practice of that day did not realize these passive cylinder-wall actions of the Cornish pump. Consequently it became gradually evident toward 1860 that the steam engines of the world were failing to realize the results due to Watt's theory. This conclusion was deduced from service records of coal-consumption tests, as from 1840 to 1860 no impressive water-consumption tests were made.

At the latter date, however, Isherwood's elaborate and thorough tests on the United States steamer *Michigan* appeared, showing a limit to the gain in steam economy by increasing ratios of expansion through the existence of some action of the steam unknown in its character but evidently not taken account of by Watt's simple theory of expansion.

Rankine's sagacious analysis of the *Michigan* data located this missing factor of the theory in the powerful waste action of the cylinder walls, constituting, with all of its complicated dependence on range of temperature, cylinder surface, speed, and jacket influence, what we now term the "loss due to cylinder condensation." It was then quickly recognized that to realize the gain due to Watt's theory of expansion, the percentage of loss due to cylinder condensation must be confined within certain limits as the ratio of expansion increased, and that it could be by controlling its main factor (the range of temperature in the cylinder during expansion), through the division of this expansion among successive cylinders.

DEVELOPMENT OF MARINE ECONOMY.

The idea of the subdivision of the range of temperature was first extensively applied in marine practice to compound the simple condensing engine using steam at 60 to 80 pounds boiler pressure with six expansions without either increasing

the boiler pressure or expansion ratio. No practical gain in economy resulted from this change, as, while the range of temperature of the cylinder was cut in two and the cylinder condensation loss thereby reduced, the gain accruing therefrom was neutralized by the mutilation of card area, due to the discontinuity of the expansion curve and the loss of pressure between cylinders. The water consumption, therefore, remained at about 19.5 pounds per horsepower, which had been afforded by the simple engine.

But the marine boiler-making art had now advanced so as to make 150 pounds steam pressure available. Therefore, the engine was able to use fourteen expansions and secure such an increase in mean effective pressure as would enable a 3-cylinder engine to weigh practically no more per horsepower than did that of the compound system. The marine world, therefore, sought the increased economy due to Watt's theory from fourteen expansions divided among three cylinders, so that the range of temperature in each cylinder was the same as that in the compound system with lower boiler pressure. The cylinder-condensation loss was thereby controlled so that the gain in economy due to the greater ratio of expansion under Watt's law preponderated over the loss due to broken card area. The result was, taking the merchant marine engines as the standard of economy, that the water consumption fell to 15 pounds per horsepower. The triple-expansion engine at sea, therefore, afforded the first real gain in economy over the simple engine of six expansions, which was prevalent when the phenomenon of cylinder condensation was discovered.

Further development of marine boiler construction now supplies the merchant marine with 210 pounds of pressure from Scotch fire-tube boilers. This permits the use of fifteen expansions with 39 pounds of total mean effective pressure, or about 30 per cent. increase over that of the 150 pounds triple-expansion engine; this, together with increased revolutions, by virtue of improvements in lubrication and construction of bearings supplemented by more perfect balancing of moving parts and no greater mutilation of card area than in the triple

engine, permits the use of four-stage expansion engines whose weight is within satisfactory commercial limits.

With the expansion divided into four stages, in four or more cylinders, the temperature range per cylinder is reduced over that of the triple engine with a resulting reduction of cylinder-condensation loss so as to afford a water consumption of 13.6 pounds per horsepower hour of the main engine, with a vacuum of 25.5 inches. This economy is attained with saturated steam without jackets or reheaters, the latter never having shown sufficient gain on marine engines to compensate for the care necessary to manage them; and it applies to all engines above 5,000 horsepower, the gain in economy due to larger size being indistinguishable by service records.

With an attached air pump, the usual auxiliaries consume steam which increases the water consumption to 14.4 pounds per horsepower of the main engine. The exhaust of these auxiliaries applied to heating the feed water, supplies it to the boilers at fully 200 degrees Fahrenheit. From this temperature Scotch boilers with Howden's system of draft, burning about 21 pounds of the best semi-bituminous coal per square foot of grate per hour, evaporate 11 pounds of actual feed water per pound of coal. Thus for each indicated horsepower of the main engine 1.3 pounds of coal are consumed per hour.

Without an increase in boiler pressure above 210 pounds, further increase in economy can only be obtained with higher ratios of expansion, and this is prohibited because the consequent reduction of mean effective pressure would increase the weight of the engine per horsepower beyond commercially acceptable limits.

With higher boiler pressure greater economy can be obtained from the engine by increasing the expansion up to probably a ratio of 30, but to accomplish this without increase of weight of engine per horsepower would require a working pressure of steam of 300 pounds per square inch. This must be obtained from water-tube boilers, as the Scotch boiler is now at the limit of practicable construction and allowable weight when built for 210 pounds steam pressure.

Higher economy of engine is obtainable, with present pressures and ratios of expansion by the use of superheated steam, but the application of the latter has not thus far shown a gain in coal economy in trans-Atlantic marine practice. This is doubtless ascribable to the use of imperfectly-designed superheaters; but the increase of cylinder oil which superheating requires makes its successful introduction at sea questionable, on account of the difficulty of protecting the boilers against over-fouling by accumulation of oily deposit.

At the advent of the steam turbine in marine practice, therefore, the degree of economy with which it must compete in marine engines on the largest scale is that of a quadruple-expansion system, expanding saturated steam with 210 pounds pressure fifteen times into a vacuum of 25.5 inches, with an economy of 13.6 pounds of water per horsepower hour of the main engine, which will operate, with its auxiliaries, from Scotch boilers on the Howden system, with a consumption of 1.3 pounds of the best semi-bituminous coal per indicated horsepower hour of the main engine.

If the turbine could operate screw propellers efficiently with the same rotational speeds for a given horsepower that it uses in electric service, the record for economy already established by the turbine shows its ability to easily compete with these conditions of performance of the best marine engine. But such rotational speeds for the turbine are inconsistent with the degree of screw propeller efficiency available from piston engines.

Therefore the possibilities as regards steam economy of the turbine in marine practice are as yet too unsettled to permit of their definite statement within the limits of this paper.

DEVELOPMENT OF STATIONARY-ENGINE ECONOMY.

Stationary engines at the date of the discovery of cylinder condensation were affording the maximum economy in simple condensing cylinders, expanding steam of from 60 to 80 pounds pressure six times, with a vacuum of about 27 inches, which

afforded a water consumption of about 19 pounds per horse-power hour.

The first noteworthy improvement upon this degree of economy was obtained in the Leavitt pump at Lawrence, Mass., which by expanding 120 pounds steam sixteen times in two cylinders, secured a water consumption of 16.5 pounds per horsepower. This, however, was a compound engine, without a receiver, or what is known as the "Wolff" system, which does not divide the range of temperature due to expansion between the two cylinders, as the high cylinder is in connection with the low during the whole of the latter's expansion period. This fact and the slow speed of 12 revolutions per minute made the initial cylinder condensation 40 per cent., or nearly twice that of the 6-expansion simple-condensing engines, besides which, live steam jackets on both cylinders consumed 10 per cent. of the total steam.

The gain in economy over the simple engine was therefore due entirely to the influence of the high ratio of expansion aided by high initial pressure and so strong a re-evaporative effect that the expansion line was outside of a Mariotte curve to the end of the expansion. The combined effect of these more than offset the negative influence of the high percentage of cylinder condensation. The engine was, however, the most economical of its time (1872), and it is interesting to note that its conditions of steam action were widely in contrast with that of the most economical Cornish pumping engine of 1840, which afforded precisely the same water consumption of 16.5 pounds by expanding 30 pounds steam three and one-half times, with a complete avoidance of loss by cylinder condensation.

The first prominent advance in economy by division of the range of temperature was obtained about 1878 in the Corliss Pawtucket compound pumping engine. This also expanded 120 pounds steam sixteen times in two cylinders, but with a receiver between them; whereby, with the aid of a speed of 50 revolutions and only 5 per cent. jacket consumption, the cylinder-condensation loss was reduced to 25 per cent., and a

water consumption of only 13.7 pounds resulted. This result led Corliss to introduce similar compound engines into mill practice, and they were then rapidly substituted throughout the world in all large power-using industries for the single 6-expansion condensing engine. All makers of 4-valve drop cut-off engines in both the United States and Europe obtained from them a water consumption of from 13.5 to 14 pounds per horsepower with about 125 pounds steam pressure and about 16 expansions.

The gain from one division of temperature being thus established, triple-expansion engines were quickly introduced for mill and electric service by Corliss and Allis in the United States and Sulzer in Germany to obtain a further gain from two divisions of temperature. None of the triple-expansion engines succeeded, however, in reducing the water consumption below 12.5 pounds per horsepower, which was not a sufficient gain over the compound engine to offset the extra cost and care of the third-expansion stage. Its use was therefore quickly abandoned in mill and electric-light service in favor of the compound engine.

Such a general readoption of the compound type resulted in a variety of cylinder ratios being used as involving possibilities of improved economy over the ratio of 4 to 1 introduced by Corliss. The first radical departure appeared in the Rockwood & Greene system, which was introduced into New England, with a cylinder ratio of about 7 to 1, and clearances of about 2 per cent., instead of the 4 per cent. value previously prevailing. With 150 pounds steam pressure, live-steam jackets on either the heads or barrels of both cylinders, and a live-steam reheating receiver, such engines have afforded 12.45 pounds per horsepower with saturated steam expanded twenty-six times into about 27.5 inches of vacuum. Without the jackets and reheater in use, about 2 per cent. greater water consumption is obtained. The jackets and reheater, when in use, consume only about 8 per cent. of the total steam, with practically 25 per cent. of cylinder condensation under both conditions.

This performance represents the best economy derived from the compound engine for mill and electric practice up to within a few years ago, and it has largely established the belief that a cylinder ratio of about 7 to 1, with so small a clearance as 2 per cent., is necessary to maximum compound-engine economy. During the last two years, however, the following records have been established :

(1) With an 850-horsepower Rice & Sargent compound Corliss engine running at 120 revolutions per minute, having a 4 to 1 cylinder ratio, clearances of 4 per cent. and 7 per cent., live jackets on cylinder heads and live steam in reheater, Professor Jacobus, of Hoboken, found for 600-horsepower of load, with 150 pounds pressure of saturated steam, 28.6 inches of vacuum, and 33 expansions, 12.1 pounds of water consumption per horsepower—a result produced with a cylinder-condensation loss of 22 per cent., and a jacket consumption of 10.7 per cent. of the total steam consumption.

(2) With a 250-horsepower Belgian Van den Kerchove poppet-valve compound engine, running at 126 revolutions per minute, with 2.97 to 1 cylinder ratio, clearances of 4 per cent., steam-chest jackets on barrels and head, and no reheater, Professor Schröter, of Munich, found 117 horsepower of load, 130 pounds pressure of saturated steam, 27.6 inches of vacuum, and 32 expansions, 11.98 pounds of water per horsepower—a result produced with a cylinder-condensation loss of 23.5 per cent., and a jacket consumption of 7 per cent. of the total steam consumption in the high-cylinder jacket and 7 per cent. in the low jacket.

(3) With the Westinghouse twin low-cylinder, compound combined poppet-valve and Corliss-valve engine, at the New York Edison plant, running 76 revolutions, with 5.8 to 1 cylinder ratio, clearances of 10.5 per cent. and 4 per cent., without jackets or reheater, Messrs. Andrew, Witham and Wells found for the full load of 5,400 horsepower, 185 pounds steam pressure, 27.3 inches of vacuum, and 29 expansions, 11.93 pounds of water per indicated horsepower—a result produced with an initial condensation of about 32 per cent.

These facts show that the minimum water consumption of the compound mill engine and electric-light engine of the present date, using saturated steam, is not dependent upon any particular cylinder ratio and clearance nor upon any system of jacketing, but that the essential condition is the use of a ratio of expansion of about 30, above which the cylinder-condensation loss is liable to prevail over the influence of the law of expansion. The conclusion appears warranted, therefore, that if this ratio of expansion is secured with any of the current cylinder and clearance ratios, and with any existing system of jackets and reheaters, or without them, a water consumption of 12.4 pounds per horsepower is possible, and that a variation of four-tenths of a pound below or above this figure may occur by the accidental favorable, or unfavorable, jacket and cylinder-wall expenses which are beyond the exact control of the designer.

COMPOUND PISTON ENGINE ECONOMY *VS.* THAT OF STEAM TURBINE.

In order to compare the economy of the piston engine with that of the steam turbine, we must use the water consumption per brake horsepower, since no indicator card is possible from the turbine; and furthermore, we must use the average water consumption for the range of loads to which engines are subject in practice.

In all of the public turbine tests to date, with one exception the output was measured through the electric power of a dynamo whose efficiency is not given for the range of loading employed, so that the average brake horsepower is not known. This exception is the Dean and Main test of a 600-horsepower Westinghouse-Parsons turbine using saturated steam at 150 pounds pressure, and a 28-inch vacuum. We may compare the results of this test with that of the 850-horsepower Rice & Sargent engine, and the 250-horsepower Belgian engine, by assuming that the power absorbed by friction in these engines is 3 per cent. of the indicated load plus the power shown by friction cards taken with the engine unloaded. The latter showed 5 per cent. of the rated power in the case of the Rice

engine and 8 per cent. in the Belgian engine; so that the assumption regarding the load friction is a reasonable one.

The results are given in the following table, which shows the average water consumption per horsepower, for from 40 per cent. to 125 of full load, to be 14.55 pounds and 14.64 pounds for the two piston engines, and 14.51 pounds for the turbine, or practical equality:

AVERAGE STEAM CONSUMPTION PER BRAKE HORSEPOWER OF PISTON ENGINE *VS.* TURBINE.

Per cent. of full load.	Pounds water per brake H.P. hour.		
	600-H.P. turbine.	850-H.P. Rice engine.	250-H.P. Belgian engine.
125	13.62	13.78	15.10
100	13.91	13.44	14.15
75	14.48	13.66	13.99
41	16.05	17.36	15.31
Average, 85	14.51	14.56	14.64

As an indication of the gain in economy of the turbine with increase of size, we may use the Elberfeld test of a Parsons turbine at the full load of 1,500 electric horsepower, with an allowance of 5 per cent. for attached air pump, and an assumed minimum generator efficiency of 0.95. Its saturated steam consumption, with 150 pounds boiler pressure and 28 inches of vacuum, is then 13.08 pounds per brake horsepowerhour, which shows a gain of 4 per cent. over the 600-horsepower machine.

The 5,400-horsepower Westinghouse compound engine at the New York Edison station, whose friction under full load was cleverly determined at about 4 per cent., affords a brake horsepower consumption of 12.5 pounds for 185 pounds boiler pressure. Crediting the turbine, therefore, with the possible influence of the difference in size and steam pressure, there is again practical equality in economy between it and the piston engine for equal horsepower.

DEVELOPMENT OF PUMPING-ENGINE ECONOMY.

While the mill and electric practice has developed the compound engine, pumping engines in the United States have been developed in the triple-expansion fly-wheel type to a degree of economy superior to that afforded by any compound mill or electric engine, and, for saturated steam, superior to that of the pumping engines of any other country. This is because their slow speed permits of greater benefit from jackets and reheaters and of less losses from wire drawing and back pressure. These causes, together with the greater subdivision of the range of cylinder, have resulted in records made between 1894 and 1900 of 11.22, 11.26 and 11.05 pounds of saturated steam per indicated horsepower, with 175 pounds steam pressure, and from 25 to 33 expansions, in the cases of the Leavitt, Snow and Allis pumping engines, respectively, the corresponding heat consumptions being by different dispositions of the jacket drainage 204, 208 and 212 thermal units per indicated horsepower minute; while later the Allis pump, with 85 pounds steam pressure, has lowered the record to 10.33 pounds of saturated steam per indicated horsepower, with 196 heat units of consumption per horsepower minute.

The turbine can compete with these pumping engines only through the medium of a multiple-stage centrifugal pump, whose efficiency, taken even at 80 per cent., will probably impose too great a loss of motive power on the turbine system for successful competition with this high class of piston pump, since the friction loss of the latter is only 5 per cent. of the indicated horsepower.

GAIN FROM SUPERHEATING AND FROM THE SULPHUR-DIOXIDE EXHAUST-HEAT ENGINE.

For opening the way to the improvement of the economy of the piston steam engine beyond any degree represented by the results we have thus far presented, we must make our bow exclusively to the Germans. By their revival of the use of superheated steam, after it had been twice abandoned in the history of steam engineering, they have demonstrated the

practical success of superheating to raise the economy of any engine, whatever its boiler pressure or ratio of expansion, by rendering the steam a more efficient working medium on its entry to the engine. By showing that after the steam has been expanded to its greatest practical limits in piston engines an important amount of power can still be practically abstracted from it in the sulphur-dioxide engine, they have also reduced the waste accompanying its exit from the engine.

Previous attempts to use superheated steam failed because of the lowered efficiency of the boiler through the location of the superheating device in the chimney. Here the superheater was so arranged that the exit temperature of the heated gases had to be in excess of the superheated-steam temperature to such a degree that the boiler's economy was lowered, and also the superheating surface so located and in contact only with steam was rapidly corroded. These defects the Germans have overcome by arranging the superheater so that it receives wet steam at the chimney end of the system, and lies at the middle of the flame current, at the point where the superheated steam is delivered from it to the engine. Thus the hot gases can enter the chimney at no higher temperature than is consistent with the best economy from saturated-steam boilers, and experience thus far shows no impracticable rate of depreciation of the superheater from corrosion.

The difficulty of conveying highly superheated steam from the boiler to the engine without excessive loss of temperature has also been overcome by improved and thicker pipe installation and the use of about half the pipe section usually employed for saturated steam. The generator plant has therefore been perfected so that it does not handicap the value of the superheated steam to the engine, while the latter is adapted to work the steam without lubrication difficulties by the use of poppet valves on at least the initial cylinder.

The maximum of improvement in economy over saturated steam may be briefly summarized in the following extract from an admirable investigation by the most distinguished European authority on engine tests, Professor Schröter, of Munich: The

engine used was the compound 250-horsepower 13 and 21 by 33-inch Belgian Van den Kerchove construction, previously mentioned, operating with a boiler pressure of 130 pounds, and 27.6 inches of vacuum, with 30.18 inches of barometer. For saturated steam the average water consumption for five divisions of load, between 40 and 125 per cent. of rated load, is 12.45 pounds per English indicated horsepower hour, with 3.6 per cent. of steam condensed in the high jacket at 130 pounds pressure, and 9 per cent. in the low jacket, including the receiver, at 5 pounds pressure. Assuming the jacket drainages applied to heat the feed water from a temperature of 108 degrees in the hot well, 136 degrees Fahrenheit feed temperature would be afforded. Reckoning the expense of heat from this temperature, the consumption is 225 thermal units per indicated horsepower minute.

With steam superheated 224 degrees Fahrenheit above saturation, or at 304 degrees centigrade, the average consumption for the same divisions of load is 10.09 pounds of feed water per horsepower. With one-third of 1 per cent. high-jacket and 3 per cent. low-jacket and receiver consumption, the jacket water would heat the feed water to 115 degrees Fahrenheit at the same hot-well temperature. Reckoning from this temperature, with a specific heat value of 0.6, according to the experiments of Lorenz and of Bach, the heat expense is 209 thermal units per horsepower minute. The average gain by superheating 224 degrees Fahrenheit is therefore 7 per cent. If the feed water were heated to 200 degrees by auxiliaries the heat unit gain would be 8 per cent.

With steam superheated 307 degrees Fahrenheit above saturation, or at 350 degrees centigrade, and the load at about 80 per cent. of rating, the water consumption was 8.99 pounds per English horsepower, with 0.4 of 1 per cent. condensation in the high jacket and 4 per cent. in the low. This affords 114 degrees Fahrenheit temperature, and with a specific heat of say 0.57 (since according to Lorenz's experiments the specific heat reduces with increase of superheat at any given pressure), we have a heat consumption of 192 thermal units per horsepower

minute. The same load with saturated steam affords 137 degrees Fahrenheit of feed temperature and gives 221 units of heat consumption per horsepower. The gain for 307 degrees superheating over saturated steam for the same horsepower is therefore 13 per cent. from the natural-feed temperature and for 200 degrees feed 14 per cent.

The best performance reported for superheated steam used in the turbine is that of Brown & Boveri Parsons Frankfort 4,000-horsepower machine, which, with 183 pounds boiler pressure above the atmosphere and 190 degrees Fahrenheit superheat, afforded 10.28 pounds per brake horsepower, assuming a generator efficiency of 0.95. Reckoning from the feed temperature of its vacuum of 27.5 inches, and using a specific heat value of 0.65, the heat consumption is 214 thermal units per horsepower minute.

The heat consumption of the 250-horsepower Belgian compound engine per brake horsepower at the highest superheating of 307 degrees Fahrenheit is 220 thermal units. The turbine, therefore, probably holds the record for brake horsepower economy over the piston engine for superheated steam by a margin of about 3 per cent., although had the compound engine been of the same horsepower as the turbine, so that its friction load would be only 8 per cent. of its power instead of the 13 per cent. here allowed, it would have excelled the turbine in brake horsepower economy by a margin of about 2.5 per cent.

THE SULPHUR DIOXIDE ADDENDA.

The most economical piston engines, which, as we have seen, expand steam about thirty times, release their steam at the end of the stroke at about 6 pounds absolute pressure, but they exhaust into a condenser, which, with a vacuum of 28 inches, contains a pressure of about 1 pound absolute per square inch. If the expansion could continue until the pressure of 1 pound was attained before exhaust occurred, considerable more work could be obtained from the steam. This, however, cannot be done in piston engines, for two reasons: First, because the low cylinder would have to be about five

times greater in volume, which is commercially impracticable; and, second, because the velocity of exit through the largest exhaust ports possible is so great that the frictional resistance of the steam makes the back pressure from 1 to 3 pounds higher than the condenser pressure in the best engines of ordinary piston speed.

All the work due to this extra expansion can be obtained, however, by exhausting the steam from the low cylinder at 6 pounds pressure, against a nest of tubes containing liquid sulphur dioxide, which thereby is boiled to a vapor of about 170 pounds pressure. This can be used to drive the piston of a separate engine or an extra cylinder attached to the main engine, and be thence exhausted into a condenser to be reliquefied. If the sulphur dioxide expands in its cylinder to a pressure corresponding to its temperature of liquefaction, and the latter is that of steam at 1 pound pressure, the work derived from the fluid is the same as the extra work which the steam would have furnished in the main cylinder by continuing to expand to 1 pound pressure and exhausting against 1 pound of constant back pressure. The greatest vacuum required in this system does not need to be more than 20 inches, which is very easily produced and maintained, as compared with a vacuum of 28 inches, corresponding to 1 pound of absolute pressure.

Professor Josse, of Berlin, has perfected this sulphur dioxide system of improvement, and reliable tests have shown that if cooling water of 65 degrees Fahrenheit is available, and to the extent of about twice the quantity usually employed for condensing steam under 28 inches of vacuum, a sulphur-dioxide cylinder of about half the size of the high-pressure cylinder of a compound engine will do sufficient work to improve the best economy of such engines at least 15 per cent. The steam turbine expands its steam to the pressure of its exhaust chamber, and as unlimited escape ports can be provided from this chamber to a condenser, it follows that the turbine can practically expand its steam to the pressure of the condenser. Therefore a steam turbine attached to a piston engine to op-

erate with the latter's exhaust should effect the same saving as the sulphur dioxide cylinder, and turbines are being applied for this purpose at present by the makers of the Rateau type.

The turbine, therefore, even at this early period of its history, is already a formidable competitor to the piston steam engine in its most economical degree, and that it is so is mainly due to the fact that with no more waste in its steam action from internal friction than is due to the cylinder-wall wastes of the piston steam engine which are absent in the turbine, it more completely realizes the expansive principle enunciated in the infancy of a steam history as the fundamental factor of economy, by its sagacious founder, the immortal James Watt.—"Stevens' Institute Indicator."

FOAMING OF THE WATER IN A STEAM BOILER AND ITS EFFECT.

By CHARLES H. HASWELL, C. M. and N. E.

There is not an element in the effective and economical operation of a steam boiler and attached engine, whether in land or marine service, and especially in the latter, that is pregnant with more results and casualties than the foaming, or "priming" of it (the latter a foreign term neither expressive nor derivative), inasmuch as it involves not only the wasted expenditures of heated water, by its flowing with the steam of operation into the cylinder of an engine, but, when its volume is in excess of that of the clearance space between the piston and the head or bottom of the cylinder, it involves the disruption of one of them. Upon the resulting arrest of the engine and consequent flow of steam to it, the foaming water, except when violently agitated by the motions of the vessel in which it is operated, subsides, and if its surface is below the upper surface of the furnace tubes or flues, as the case may be, it soon renders them incandescent, and as the result a collapse may ensue.

Before essaying to submit a remedy, or even an amelioration of this objectionable and destructive operation of foaming, it

is proper to consider its origin. Ordinarily, it is the result both of an insufficient height and volume of steam space above the water line and the *per saltum* flow of steam to the engine, consequent upon the periodic operation of the steam valves, which involves such undulations of the surface of the water that foaming ensues. It also occurs when the area of the surface of the water is less than that of the area over the crowns of the furnace.

With boilers, where foaming exists, various expedients are resorted to, either to obtain additional volume of steam space by the addition of a cylindrical vessel, arranged as an integral of the boiler or attached to it, termed the drum, or by concentric cylinders set vertically at the termination of the flues or tubes, and rising to an elevation so far above the water level as to give space for the foaming water to subside before reaching the opening of the steam pipe. Upon this construction the smoke pipe is set, and the hot air from the furnace rising through the inner cylinder or chimney superheats the steam within the ring to an effective and economical degree. Another method is to extend the steam pipe into the boiler and attach it to the under side of the crown of the shell. The pipe is perforated with numerous small openings, and the steam, instead of flowing in a mass to the opening of the steam pipe, flows in minute currents from an extended surface, and foaming is materially arrested. This construction is termed a dry pipe.

Foaming renders it difficult, furthermore, to readily ascertain the actual height of the water in a boiler; and as the removal or correction of this difficulty is imperative, various devices, in addition to the ordinary gauge cocks of manual operation, areused, such as a glass gauge attached to the front of a boiler and connected to it, both above and below the upper surface of the flues or tubes, by small connections, which arrest and reduce the foaming to a degree that shows the actual height of the water. Sometimes a metallic cylindrical vessel with a glass face is used, connected in like manner.

The loss in the cylinders from the superhydrated steam due to foaming water is a material element in the question of the economy of a steam engine. The conditions, results and constructious here detailed are well known, and they are introduced, not only as a record of the construction of the period, but to give value to the following illustration of a very common and effective cause of foaming in all boilers, and how it can be materially prevented.

In the operation of the furnace of a boiler, the heated water contiguous to the outer sides of it rises in vertical currents to the water line, and in a boiler where the water line is less in width than the extreme width of the furnaces, the ascending of currents of water in the condition of ebullition will be concentrated at the water line between the sides of the boiler and furnace; and hence a concentrated ebullition of the surface of the water or foaming much in excess of that which arises from the ordinary want of steam space will ensue, which in small marine vessels, where the height under the deck is insufficient to admit of a drum, chimney or like construction, is irremediable.—"Scientific American."

TRIALS OF THE TROOPSHIP *DUFFERIN*.

The troopship *Dufferin*, built and engined by Messrs. Vickers Sons & Maxim, Limited, at their Naval Construction Works, Barrow-in-Furness, for the Royal Indian Marine, completed on the 23d instant her official steam trials, and will leave in about ten days for Bombay. The prescribed trials were six runs over the measured mile at 18½ knots, with six hours' continuous steaming at full speed. These tests took place on the measured mile at Skelmorlie, on the Clyde, the vessel being loaded to her full displacement of 7,340 tons, the draught being 19 feet. A mean of mean speed of 18.897 knots was attained with the engines indicating 9,975 indicated horsepower. The six runs showed remarkable uniformity, as is indicated by the following details:

.....	Mean revolutions.	Mean indicated horsepower.	Time.		Speed.
			min.	*sec.*	*knots.*
First run..	117	9,421	3	12	18.75
Second run.....	117.3	9,935	3	11¼	18.83
Third run.....	118.6	10,365	3	9⅝	19.006
Fourth run.....	118.4	10,135	3	10½	18.898
Fifth run.....	117.8	10,167	3	10⅜	19
Sixth run.....	117.6	9,827	3	10½	18.872

On none of the runs was the speed less than that contracted for, while at no time did there seem any reason why 19 knots should not be maintained for an indefinite period. The mean results, so far as engine performance, are given in the first column of the appended table, while the averages of the hourly readings on the six-hours' test are set out in the second column. It will be noted that the mean power was 9,881 indicated horsepower, and this was maintained very easily and steadily, a characteristic of the design of engines being their ample bearing surfaces.

FULL-SPEED TRIALS OF R. I. M. S. *DUFFERIN.*

.....	Mean of six runs over measured mile.		Mean of six hours' sea trial.	
	Stbd.	Port.	Stbd.	Port.
Mean steam in boilers.....	177.3	177.5	179	179
at engines.....	175.6	175.7	178	178
air pressure.....	2	2	2	2
cut-off in M.P. cylinder.....	70.8 p. c.	70.4 p. c.	71.4 p. c.	70.8 p. c.
vacuum.....	26	25.5	26	26
revolutions.....	117.5	118.1	115.2	116.3
pressure in cylinders, high.....	77.48	75.34	79.8	78
intermediate,	32.4	32.5	32.6	33.6
low	14.8	14.64	14.8	13.5
Indicated horsepower, high.....	1,560	1,526	1,575	1,554
intermediate.....	1,604	1,614	1,568	1,645
low.....	1,819	1,852	1,849	1,690
Total indicated horsepower.....	4,983	4,992	4,992	4,889
Gross total indicated horsepower.....	9,975		9,881	

We described the ship in connection with the launch, but here some reference may be made to the special fittings since

added to the ship, which, by the way, was designed by Sir Edward Reed, K. C. B., the Consulting Naval Architect for the Royal Indian Marine. Built primarily as a home trooper, the *Dufferin* is fitted and adapted in every way for the transport of native troops as well as European and for ordinary trooping service in India. It is a satisfaction to note that in her everything has been done to insure the comfort of "Tommy Atkins" while afloat. Although 100 feet longer than the *Warren Hastings*, built about twelve years ago by the same firm, the number of European troops carried is the same—viz: 1,100—the additional size allowing for the increased and improved accommodation now demanded for all ranks. Steam-heating pipes are fitted throughout the living spaces below the spar-deck, and electric radiators in the officers' cabins, smoke room, &c., above this deck.

The ventilation of a ship of this class presents very considerable difficulties, more especially as it is imperative to keep the decks clear of ventilating cowls and other obstructions for the massing and drilling of troops. This consideration has led to the adoption of artificial ventilation by means of electric fans throughout the troop spaces, hospitals, stores, &c., with the result that the spar deck on each side is absolutely free from obstructions of any sort for a length of over 250 feet. A special feature is also the fitting of square ports on the sides of the hull throughout the saloons and cabins on the main deck, and throughout the troops' spaces, hospitals and women's quarters on the troop deck. These square ports are fitted with sliding glass sashes, and along the troop deck with sliding jalousie blinds as well. Special arrangements have been made for opening and closing the troop deck ports from inside the ship. The panelling in the saloons, music room, smoke room, &c., is of hard wood throughout, and the cabin fittings generally, while being of quiet and good appearance, are strong and durable.

The decks and other woodwork of the ship are, with few exceptions, of Burmah teak, light wood being unsuitable, for many reasons, in the Indian climate. The sanitary arrange-

ments are very complete, and marble baths are fitted for the ship's officers and first-class passengers. A large hot-water tank supplies these and other baths with hot salt water. Fresh and cold salt water are also laid on. A large copper firemain extends from end to end of the ship, with frequent nozzles, and with a length of india rubber-lined hose at each nozzle. The cooking plant is extensive, there being four special ranges for native troops in addition to the galley ranges ordinarily arranged for passengers, European troops and crew. Large cold-storage rooms for meat and vegetables, cooled on the CO_2 gas principle, and an ice-making plant are also fitted. For ready use a provision store and ice room have also been placed on the main deck. A special cooled, filtered drinking-water service has been laid on to the pantries and bars. A soda-water machine has been fitted in a separate compartment on the orlop deck adapted for filling either syphons or glass bottles. There is also a bottle-washing machine. The storerooms, which are numerous and large, are constructed with stamped steel and netting to allow of a free circulation of air throughout them.

The hospitals for troops and women are fitted up complete, in accordance with the latest troopship practice, with all the usual cots, cot lifts, electric fans, portable electric lamps, electric kettles, electric heater for sterilizer, etc. A special hospital for the native crew has also been arranged and similarly fitted.

Admiralty practice has been adopted largely as regards ship's fittings and outfit, of which the following may be mentioned: Electric lighting, wiring and fittings, fire main, water-tight doors, sluice valves, night life buoys, compasses, voice pipes, hand pumps, masthead and gravity signalling lamps, semaphore, mess tables and stools, and helm signals. The electric plant consists of three compound closed-in engines, directly coupled to 50-kilowatt dynamos, also made by the Vickers Company. The voltage is, as in recent Admiralty practice, 100. The searchlight projector is portable, and is adapted for use in the ordinary way, or for being hung over the bows

in a cage, for navigating in the Suez Canal. A powerful arc light for anchoring purposes in the Suez Canal is also supplied.

The ship has been fitted with Rothwell's patent davits and boat chocks, which greatly facilitate the getting out of the boats in a time of emergency. In accordance with the latest and best mercantile practice in this country and in Germany, the Stone-Lloyd system of controlling the watertight doors of the ship from the bridge has been adopted.

The ship has been designed for use as an auxiliary armed cruiser in time of war, and is adapted to mount eight 4.7-inch quick-firing guns and a number of guns of smaller caliber. Special watertight compartments have been arranged for the fitting up of magazines when desired, these spaces in ordinary trooping service being utilized as stores.

The *Dufferin*, unlike the previous troopers built for the Royal Indian Marine, has been completely fitted up in this country with all troop fittings, including mess tables and stools, sea-kit racks, accoutrement hooks, sleeping boards, hammock bars and hooks, mess racks, &c., so that on her arrival in India she will be ready, in all respects, for commissioning.—"Engineering," London, December 30, 1904.

A ONE-SIDE DRYDOCK.

A new floating dock has recently been added to the large number of similar docks in the port of Hamburg. At this port the floating dock is almost the only type of ship-repairing structure used. The particular dock illustrated differs from most others in Hamburg in some of its structural features. It was necessary to comply with some peculiar conditions. The river was so narrow at the place where the dock was to be used that no mooring rights could be obtained in the stream, so as to exclude any possibility of using the ordinary double-side type of dock, into which vessels enter by the end. The one-sided type was adopted accordingly.

The dock was designed to have a maximum lifting power

of 11,000 tons, and is tied to the shore by nine sets of double parallel booms, of which two are A-shaped, so as to be able to lay hold of the dock also in its longitudinal direction, and to prevent any vibrations. To the same effect were provided two additional sets of booms, which are strongly cross-braced into pairs. The columns are built into concrete sockets formed by steel cylinders that are sunk into the river bed. These were filled with concrete after the soil had been removed. They are tied to the shore by means of steel ties fitted into concrete, all the columns being connected by means of lattice girders. The end and central booms serve as gangways leading to the top deck, while in addition to these, broader gangways lead down to the pontoon deck, passing through passages in the walls.

The over-all length of the dock proper is 508.4 feet. The bow is tapered, and has a length of 73 feet. The stern is approximately square on the land side, but the river side is tapered off to the same angle as the bow. The maximum beam of the dock is about 100 feet, the position of the keel blocks being such that the maximum beam of vessel to be taken is 76 feet, so that a working space of 4 feet between the side of the ship and face of the wall is allowed. The normal draught of the dock is 22 feet.

The machinery plant is located in the dock between the two longitudinal walls; it consists of eight sets of 18-inch centrifugal pumps driven each by a compound, horizontal engine, direct-connected with the pump shaft. According to the contract, the engines had to be of sufficient power to lift an 11,000-ton vessel in at most one and one-half hours. On the official trial they succeeded in lifting a 10,000-ton vessel in one hour, which may be called a very satisfactory result. The steam necessary for the operation of the engines is supplied from a set of boilers placed on shore, the steam being conducted to them through articulated pipes running along the shore booms. The whole pumping plant is operated from a central point, *i. e.*, the valve house, so as to be under excellent control. From this valve house is effected by hydraulic means

the operation of the sluices, a small automatical semaphore indicating whether a particular gate is open or locked, while a water-level indicator accurately records in the valve house itself the exact amount of water in each compartment. The valve man is also in direct communication, by means of speaking tubes, with each engine, so as to control everything from his place.

In order to be able not only to lift vessels rapidly, but to berth them in as short a time as possible, special facilities had to be provided for. Powerful steam capstans were placed for this purpose on the top deck, whereas a series of mechanical side shores were provided in the wall of the dock, which can be screwed out to any desired extent, so that the centering of a ship over the keel blocks can be ascertained with safety.

In addition to the twenty ordinary mechanical side shores, ten very large and powerful hydraulic shores were provided, which are so arranged that, while advancing slowly, they can be withdrawn very rapidly, so as to enable ships entering the dock sideways to be placed in position rapidly and safely. The bilges of the ship are supported by means of mechanical bilge shores, consisting of watertight steel cases and worked from the top deck. They are fitted with a timber lining, one end being pivoted to the deck, while the other is raised by means of a steel rack and pinion actuated by a crank mechanism.

Both the engine and other rooms are provided with electric-light installation, arc lamps being carried on gallows on the top deck for outside illumination, while numerous flood boxes have been fitted, whence separate lamps may be taken for lighting any desired spot. For the washing of vessels, testing of tanks, and the thawing of the valves of the dock in winter, there have been provided cold and hot-water mains.—"Scientific American" Supplement.

HARMET STEEL PROCESS.

In recent years there have been recurring accidents in bursting of guns in firing. The guns were most carefully con-

structed, from the best structural steel obtainable in the United States. This steel was tested most fully at every step of manufacture, and was only accepted when it met, in the physical tests, a very high standard of requirements. In endeavoring to determine the reasons for the occasional shortcomings, investigations were made in 1901, both as to what might be designated the intimate structure of the steel when in the ingot and after forging. The board on test of metals dissected two steel ingots, one being of carbon-steel and one nickel-steel. These ingots were found full of small interior cavities, resulting from the continual contractions of the metal when passing from the fluid to the solid state. There was also a considerable piping in the interior of the ingot.

Notable variations in chemical constituents in different parts of the ingots were found to exist. This was caused by what is called liquation and segregation, the occurrence of which appeared to be unavoidable in all methods in use. No amount of forging could eliminate the interior cavities referred to. They were simply "squeezed" together and lengthened by the act of forging. There being no adhesion in these flattened cavities, they are necessarily elements of weakness.

Investigations were made by the Ordnance Department, U. S. A., in 1901. Some rings, analogous to the rings forged for guns, were turned down. "Streaks" were found in many places, and it was obviously the result of the shrinkage cavities previously mentioned. Where these occurred the metal structure was necessarily weak. This was shown more fully when the rings were subjected to hydraulic pressure until they burst. The lines of breakage were where the streaks were most in evidence.

It is claimed for the Harmet process that it presents the economic advantage in that a larger proportion of the ingot is acceptable for gun, armor and other forgings admitting only of perfect metal. It is to be tested in this country, the Ordnance Department having ordered from abroad a 10-ton ingot for trial. The French government now accepts the Harmet process steel ingots with five per cent. of wastage, instead of

twenty-eight demanded for the uncompressed steel ingots, and there is further economy, as it was found that the Harmet steel, with but two forgings, gave as good results in impact tests as the uncompressed steel gave in four forgings.

Summarizing, the claim for steel made by the Harmet process is: that it is more perfect in its physical structure, free from shrinkage cavities and piping; much more uniform in its chemical composition; gives twenty-five per cent. more available metal in the ingots produced, and requires a much smaller amount of forging to secure the best results. The process is used at Cammels' and Beardmore's in England. It is also now being installed by John Brown and Company and Firths, whilst other establishments are preparing to use it. It is in successful operation at the Oberbilk Works at Dusseldorf. It is, however, conspicuously absent in the steel establishments of the United States.—"Army and Navy Journal."

LONG RUN OF A TURBINE.

One of the most remarkable runs on record for a steam engine is that made by the 400-kw. Parsons turbine set exhibited by the Westinghouse Company at the St. Louis Exposition.

This turbine was started on the 20th of June and operated continuously until after the close of the exposition, on December 2d, the number of hours in operation being 3,962 at a speed of 3,600 revolutions per minute, making a total of 855,792,000 revolutions. An examination after shutting down showed the machine to be in excellent condition.

The set, in connection with a vertical and a horizontal gas engine, was used to supply light and power for the Westinghouse Company's extensive exhibit.

ARMOR CONTRACTS.

Contracts for the armor of the battleship *New Hampshire* and armored cruisers *North Carolina* and *Montana* have re-

cently been awarded to the Bethlehem Steel Company and the Carnegie Steel Company; the former company will furnish that for the battleship and one cruiser, amounting to 5,666 tons, together with 94 tons of bolts and nuts, while the latter will supply 2,162 tons of armor for one of the cruisers.

The bid of the Midvale Steel Company was lower than either of the others, and this company would have been awarded the contract but for the fact that the plant is not as yet considered to be in a condition to furnish armor in quantities sufficiently large to prevent delay in the construction of the vessels.

TEST OF SUBMARINE BOATS.

A despatch from Newport News, Va., February 1, says: The Lake submarine boat, *Simon Lake X*, in her final test in James River today, broke the world's record submergence. She filled her superstructure in nine and one-half minutes. The record held by a French type is fifteen minutes. With decks awash she submerged in a depth of thirty-eight feet and arose to the surface in thirty seconds. The best time made by French type is one minute. The vessel's speed was as follows: Nine and one-half knots on surface; eight and one-half with decks awash, and six knots submerged. Commander Land, of the Argentine Navy; Captain de Chair, of the British Navy, and two other foreign officers were aboard during the tests.

The boat has been sold to a foreign government, and will be dismantled and shipped shortly. Inventor Lake left here today, and on February 7 will sail for Hamburg. It is stated that he has just secured contracts abroad amounting to more than $2,000,000.—"Army and Navy Register."

PORT OF NEW YORK, 1904.

During the year 1904 there arrived at the port of New York a total of 11,279 vessels exclusive of tugs, barges and small craft. Of this number 4,035 came from foreign ports,

the greater number being of British registry, the second largest number of American registry, followed by German and Norwegian vessels. The remainder of the arrivals were from coastwise ports, 3,781 being from southern ports and 3,463 from eastern ports. Of the foreign arrivals 3,158 were steamers and 877 sailing vessels. Compared with the arrivals of the year 1903 there is a decrease of 975 vessels. The foreign arrivals increased twenty-two vessels, the southern arrivals decreased eighty-three vessels and the eastern arrivals decreased 914 vessels.—"Marine Review."

NEW DRYDOCK.

Contracts for a $150,000 floating drydock have been awarded to the Thompson Drydock Construction Co., of New York, by the New Orleans Shipbuilding & Drydock Co., the new dock being designed to hold vessels up to 5,000 tons and to replace the old Good Intent drydock. The new structure will be, after the navy dock, the largest in the Crescent City, measuring 330 feet long, 95 feet wide, and will draw at light draught 4 feet. It will be located just below Algiers Point, on the Algiers side of the river, where the company owns some 1,100 feet of frontage. The new dock is a direct consequence of the 2,500-ton dock recently completed at Mobile, which it was thought by New Orleans shipping men would probably draw considerable trade from them. About two hundred men will be employed when the dock goes into service.—"American Syren and Shipping."

WELDING TEST WITH THERMIT.

At the experimental test to decide the adaptability of the Goldschmidt thermit-welding process to marine repair work, held at the yard of the Dundam Towing and Wrecking Co., in Chicago last week, several hundred prominent marine and foundrymen saw a 7-inch anchor stock solidly reunited in less than half a minute. The process consists in fusing a chemical mixture of aluminum and iron oxide in which steel shav-

ings have been mixed, in a mold fitting over the fracture. When burning the mixture attains a degree of 5,000 Fahrenheit. As an illustration of the fusing power of the mixture, a heavy steel plate was perforated by a jet of the blazing liquid as cleanly as though struck by an armor-piercing shell. The test was entirely satisfactory, and is believed to be of much use in marine lines.—"Marine Review."

(For a description of this process, see page 319, No. 1, Vol. XVI.)

OIL IN BRITISH NAVY.

Notwithstanding the conclusion reached by engineering experts of the United States Navy, after prolonged experiments, that the uncertainty of natural supplies of crude petroleum made it unadvisable to adopt that commodity for fuel purposes on warships, the British naval authorities have decided to install apparatus for the use of oil fuel on all the batteships of the Atlantic fleet, as well as on those of the new *King Edward VII* class. This policy has been agreed upon as the result of experiments carried out on two torpedo-boat destroyers with a new oil burner, the principle of which is kept secret, but which is said to generate forty per cent. more steam from each pound of oil than can be derived from a similar quantity of the best Welsh coal. The tests alluded to have demonstrated that oil fuel is no more harmful to a ship's boilers than coal of the best quality, while the labor required to handle it is less than half. The Admiralty are fully aware that oil can never be used as the principal fuel, but only as an auxiliary, owing to the uncertainty of supply, and because of this knowledge the installation of oil-burning apparatus on so many large vessels is significant of some concern regarding Great Britain's coal resources. A royal commission, which recently investigated the whole matter, has reported that England and Wales have still enough coal to last 450 years at the present annual output, the Welsh fields containing an estimated total of 3,397,-

000,000, which is being mined at the rate of 18,000,000 tons a year, about six per cent. of which is used by the navy. The commission gives warning, however, that while the coal deposits are so rich as to afford no cause for apprehension, the cost of production is sure to increase with the increasing difficulty of mining, and that consequently it is a national duty to economize consumption by adopting all operative measures for the prevention of waste. It is evidently with that object in view that oil-burning apparatus is to be installed in a large number of important ships of the British fleet. If the new burner, for which so much is claimed, proves capable of producing steam for ordinary cruising purposes, economically, without involving increased wear and tear for boilers and machinery, the general subject of liquid fuel may become a matter of renewed interest in other navies.—"Army and Navy Journal."

TABLES FOR WORKING INDICATOR CARDS.

F. W. BARTLETT, LIEUT. COMMANDER, U. S. N.

These tables explain themselves and have been found of great use on board the *U. S. S. Chicago.* They may readily be changed to suit the number of cylinders or engines. The blank card with no name of ship or value of constants is intended as a suggestion for a Form to be added to those sent from the Bureau of Steam Engineering, made with perhaps six cylinders and three engines. They could then be used with all engines in the service. The same system of checks could be used. By adding across and up and down the checkage is made without the necessity of adding the columns twice for safety.

In case blanks are not supplied, it is possible to have Forms printed like the one marked for the *Chicago* on each ship. In case there is no printing press, the typewriter supplies its place, as many as eight or nine copies may readily be made.

U. S. S. *CHICAGO.*

Steam pressure.			
Cut-offs.	H.P.	I.P.	L.P.
S.			
P.			

Indicator Card No. *190*

STARBOARD ENGINE.

	H.P. out.	I.P. out.	L.P. out.	
P.	1.	1.	1.	
N.	1.	1.	1.	
C.	1. 8.949	1. 9.305	1. 9.661	
I.H.P.	1.	1.	1.	Out.
	H.P. inb.	I.P. inb.	L.P. inb.	
P.	1.	1.	1.	
N.	1.	1.	1.	
C.	1. 8.930	1. 9.297	1. 9.657	
I.H.P.	1.	1.	1.	Inb.

Cyl. S. Eng. S. Eng.

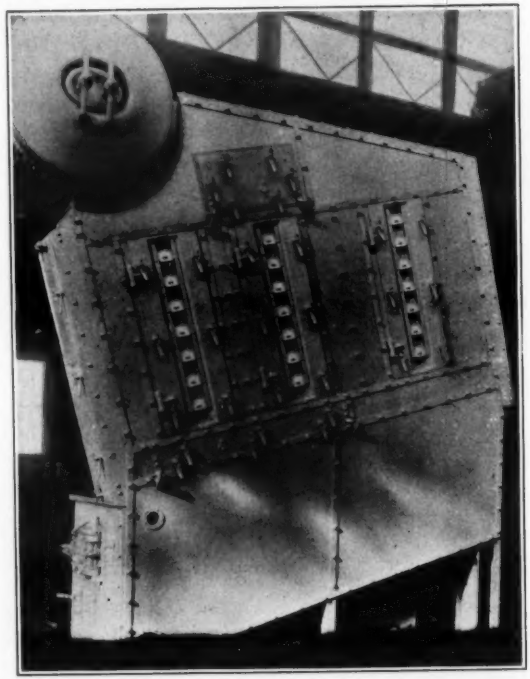
PORT ENGINE.

	H.P. out.	I.P. out.	L.P. out.	
P.	1.	1.	1.	
N.	1.	1.	1.	
C.	1. 8.949	1. 9.305	1. 9.661	
I.H.P.	1.	1.	1.	Out.
	H.P. inb.	I.P. inb.	L.P. inb.	
P.	1.	1.	1.	
N.	1.	1.	1.	
C.	1. 8.930	1. 9.297	1. 9.657	
I.H.P.	1.	1.	1.	Inb.

Cyl. P. Eng. P. Eng.

BOTH ENGINES.

Check. Total I.H.P.



Babcock & Wilcox Boiler, Built for U. S. Naval Academy.

BABCOCK & WILCOX BOILERS.

The following notes, furnished by Commander W. N. Little, U. S. N., Inspector of Machinery for U. S. Navy at the works of the Babcock & Wilcox Co., Bayonne, N. J., will prove of interest, especially when considered in connection with the article on the latest type of this boiler by Lieutenant R. K. Crank, U. S. N., in No. 4, Vol. XVI, of the JOURNAL.

The notes and illustrations refer to a boiler recently built for the purpose of instruction at the U. S. Naval Academy.

The cast-iron baffle plates shown distinctly in the photograph, are held in place by friction between the tubes and plates, and are fastened to the side framing of the casing. Clamps between the side casing and the boiler tubes are shown in the picture explaining the supports to the casing. Usually the "mud" box connecting lower ends of all front headers is supported on a shelf bracket, not shown in picture, bolted to the vertical side box. The steam drum also acts as a girder suspending the front headers between the middle and side headers, the end and middle top nipples being surrounded by sleeves between header and drum upon which the drum rests. The hollow cast-iron baffle blocks resting on the lower 4-inch tubes are protected from the initial temperature of discharged gases of furnace by a course of fire bricks as shown, and in front of this baffle block may be seen the upper edge of the first baffle of fire brick resting on and filling space between front parts of the lower 4-inch tubes immediately over the furnace. To install the cast-iron baffles between tubes, the latter are separated very slightly by inserting and rotating a rod of flat iron between the tubes. In the right lower side casing, near front, is an opening over a brass plug screwed into the corner box abreast nipple between end of mud drum and corner box, to facilitate expanding said nipple.

As additional useful data in reference to these boilers so generally installed in our Navy, I offer the following table of water weights for one boiler of each vessel named.

WEIGHTS IN POUNDS, COLD WATER.

Names of vessels.	Sections.		Lowest gauge cock.	Middle gauge cock.	Highest gauge cock.	Full.	Cold water temperature, deg. F.	Hot water at middle cock, pounds weight.*
	No.	Length.						
		ft. ins.						
Maryland	27	8 2	15,594	17,806	20,059	23,239	61.9	15,126
West Virginia	27	8 2	15,220	18,148	20,461	23,321	64.5	15,419
South Dakota	27	8 2	15,686	17,831	20,078	23,218	46	15,133
California	27	8 2	15,718	17,736	19,968	23,086	56	15,059
Tennessee	27	8 2	16,117	17,742	19,476	23,236	68.1	15,081
Washington	27	8 2	15,616	17,905	20,126	23,266	46 to 66	15,208
Nebraska	30	8 2	16,913	19,532	21,974	25,584	62	16,592
New Jersey	30	8 2	17,014	19,386	22,059	25,418	48	16,454
Rhode Island	30	8 2	16,891	19,225	21,725	25,263	56	16,324
Connecticut	25	9 2	15,309	17,353	19,503	22,503	74	14,760
Louisiana	25	9 2	15,449	17,691	19,683	22,463	68	15,105
Minnesota	25	9 2	15,167	17,384	19,548	22,488	57 to 67	14,759
Kansas	25	9 2	...	...	...	...	...	...
Vermont	25	9 2	...	...	...	...	...	...
Charleston	23	9 2	13,674	15,667	17,652	20,252	72	13,322
Milwaukee	23	9 2	13,663	15,606	17,614	20,274	60	13,326
St. Louis	23	9 2	13,769	15,663	17,723	20,343	74	13,384
Dubuque	15	8 2	7,522	8,818	10,037	12,033	74	7,535
Paducah	15	8 2	7,680	8,895	10,108	11,986	72	7,598
Indiana	20	7 11	11,140	12,825	14,510	16,870	72	11,155
Monterey	18	8 2	90,06	10,515	12,041	14,181	78	9,236

*Temperature of hot water, 411 degrees (steaming pressure 265 pounds), except in the cases of the *Indiana* and the *Monterey*, which temperature is 377 degrees (steaming pressure 175 pounds by gauge).

ADMIRALTY TRIALS OF A YARROW WATER-TUBE BOILER.

Through the courtesy of Messrs. Yarrow and Co., Limited, of Poplar, we are able to give below the results of trials made for the Admiralty on one of the Yarrow boilers for H.M.S. *Warrior*. Four-fifths of the boilers of this vessel are to be of the Yarrow water-tube type, the remainder being cylindrical boilers; but in the new boats water-tube boilers are to be used exclusively. The engines are to indicate 23,500 H.P., and there will be nineteen Yarrow boilers of four different sizes. The one tested was of the largest pattern, having a heating surface of 3,163 square feet, and a grate area of 53.35 square feet.

SUMMARY OF EVAPORATIVE TESTS ON ONE OF NINETEEN YARROW BOILERS SUPPLIED FOR H. M. S. *WARRIOR*.

Heating surface, 3,168 square feet; grate surface as measured, 53.35 square feet; burning 24 pounds, 36 pounds, and 48 pounds of coal per square foot of grate; ratio, $\frac{H.S.}{G.A.} = 59.3$.

Carried out at Messrs. Yarrows' Works, Poplar, January 16, 17 and 19, 1905.

Coal per square foot of grate surface per hour.	Average steam pressure.	Average draught of air in the base of funnel.	Temperature of the feed water.	Pounds of coal burnt during the eight hours.	Pounds of water evaporated during the eight hours.	Pounds of water evaporated per pound of coal actually.	Pounds of water in separator.	Equivalent pounds of water evaporated from and at 212 deg. F. per pound of coal.	Water from and at 212 deg. F. per square foot of heating surface per hour.	Water from and at 212 deg. F. per square foot of grate surface per hour.
lbs.	*lbs.*	*in.*	*deg. F.*							
24	206.5	0.15	40	10,242	96,750	9.446	There was no water collected in the tank from the separator.	11.664	4.72	279
During the first four hours the back damper was closed, but the two center furnace doors were slightly open.										
36	208.8	0.775	38	15,365	136,310	8.871		10.974	6.65	394
48	208	1.03	38	20,487	182,800	8.922		11.038	8.93	530

Each trial lasted eight hours. Height of funnel, about 31 feet 6 inches to fire-bar level. When burning 24 pounds per square foot of grate surface, the steam jet in the funnel was not used. For the other two trials the draft was assisted by the steam jet in the funnel. The coal used throughout the trials was Ocean Merthyr. Readings, &c., were taken half-hourly, and the figures given are the mean results. On January 21 and 22 a leakage trial was carried out. The stop and safety-valve orifices were blank flanged, and a pressure of 210 pounds was maintained for 24 hours. At the end of this time no leakage was recorded.

The specifications contained the following requirements as to coal economy:

Rate of coal consumption per square foot of grate per hour, pounds.	Equivalent evaporation from and at 212 degrees Fah., not less than pounds.
24	10
36	9½
48	9

These requirements, it will be seen from the tabulated results, were much surpassed at the trial. In the leakage test, which lasted 24 hours, blank flanges were placed over the stop and safety-valve orifices, and the pressure inside the boiler raised to 210 pounds per square inch. There was no leakage whatever.—"Engineering," London.

CONNECTICUT-LOUISIANA CONTEST.

The Department of Commerce and Labor has completed the investigation ordered by the House Labor Committee on the question of the desirability of the enactment of Gompers' eight-hour bill, and the report has been forwarded to Congress. An especially interesting feature of the report is the statistical data concerning the *Connecticut-Louisiana* contest, the *Louisiana* being built at the yard of the Newport News Ship Building and Dry Dock Co., Newport News, Va., and the *Connecticut* at the New York Navy Yard. The statistics on their face would seem to demonstrate the superiority of the eight-hour system when applied to ship building, but the Labor Bureau was careful to explain the reasons for this apparent advantage, which are so conclusive as to form a complete offset. The statement merely proves that the New York Navy Yard is working with the perfect system and straining every energy to prove that it can build a battleship. Every man and every minute is counting with it. The Newport News Co. is building the *Louisiana* precisely as it would build any other ship, without regard to the amount of work performed per man per hour. The committee does not attempt to make any record of cost, which is, of course, a vital consideration in any enterprize.

Summarizing the results of hull construction, it is found that the average man at the New York Navy Yard accomplished as much every ten minutes as the average man at Newport News accomplished at every twelve minutes and twenty-five seconds, but in a day of ten hours the average man at Newport News worked in two-tenths of a pound more than the average man in the New Yord Navy Yard in a day of eight hours.

It was determined by the Newport News officials that the building of the hull offered the best and most available basis of comparison, and they contended and agreed to compile the weights of the structural material worked into the hull and the aggregate hours of all labor employed in the items of hull construction specified by them. The New York Navy Yard did the same for the *Connecticut*.

This comparison shows that the average production per man per hour on the *Connecticut* exceeded by 24.48 per cent. the average production per man per hour on the *Louisiana*, and in the opinion of the Labor Bureau explains why the progress on the *Connecticut* in the reports of percentage of work completed to the Bureau of Construction and Repair has kept pace with the percentage reports of work completed on the *Louisiana*.

The work on the *Louisiana* has been performed in the regular way and under normal conditions, while that of the *Connecticut* indicates the putting forth of unusual and extraordinary effort and energy. The reasons why this should be so called for further inquiry into prevailing conditions and elicited the following:

1. Higher rates of wages are paid at the Navy Yard than by private companies in Greater New York and elsewhere, and the rates of the latter average higher than companies elsewhere.

2. Employment the year around is steadier and more secure than in private yards.

3. The higher wages, shorter hours and steady employment attract the best grade of workmen to the Navy Yard, where a

tacit recognition of an asserted economic theory prevails that the best workmen cannot be induced to work extra hard without larger pay than the average.

4. Prompt recognition of good work by advance in wages and promotion in grade.

5. A large waiting list of mechanics and others from private shops to select from.

6. The expectation or belief that if the *Connecticut* was built in record time the building of another battleship would be given the Brooklyn Yavy Yard.

7. A zeal generated by the general challenge of the country to the Navy Yard workmen to make good their claims in this test.

8. Prompt discharge for inefficiency.

9. Dismissal of workmen who could not or would not come up to a required standard of output in quantity and quality.

10. No restriction of output individually or collectively.

11. Loafing, soldiering or "marking time" not tolerated.

12. Workmen required to begin work the moment the whistle blows, and to continue working until the moment the whistle blows at quitting time.

13. Strict technical and exacting supervision of a high order of skill and experience.

14. A desire on the part of naval constructors and workmen to remove an impression of inefficiency growing out of former navy-yard construction of war vessels, before civil service regulations controlled employment there.

The report closes with the following pointed comment:

"Former investigations of industrial conditions, together with the facts brought out in this, lead to the following conclusions: Notwithstanding the remarkable achievement of the naval constructors and the workmen at the Navy Yard, probably unsurpassed in American industrial history, and the other notable examples in some of our great establishments in bringing out the best efforts and energy of their employés, it does not follow, when the facts presented by manufacturers

are considered, that an eight-hour work day is possible under prevailing conditions, or that labor unions and shop management in general have reached a plane that would make it possible."—"Marine Review."

THE STEAM TURBINE FOR MARINE USE.

In his presidential address to the Institute of Marine Engineers, the Hon. C. A. Parsons, C. B., dealt with the past, present and future of the steam engine. He pointed out that James Watt, had clearly enunciated the principles governing the expansive action of steam, but it was impossible to apply these to the fullest extent in a reciprocating engine. In a warship at full power the ratio of expansion was only 5½ to 1, and in economical triple-expansion mercantile engines about 25 to 1. Nevertheless, with steam at 200 pounds pressure, and 27 inches vacuum, the volume at the lower pressure was 100 times that at the high, so that even in mercantile vessels the principle of expansion was not pushed to its limit. With a steam turbine the steam could be fully expanded, and trials with a number of different vessels showed that the turbines were economical, not only in the first little experimental *Turbinia*, running at 32 knots, but also in ocean-going passenger vessels of but 16 knots speed. From the experience gained he thought that ultimately the turbine would supersede reciprocating engines in all vessels of over 16 knots speed, and taking 5,000 indicated horsepower and upwards. It might also be used for vessels of but 13 knots speed, if of 20,000 tons and upwards, and perhaps even in slower vessels as time went on. As matters stood, about one-fifth of the total steam tonnage of the world was suitable for propulsion by steam-turbines; and as improvements were effected, this fraction would tend to increase. In vessels of the tramp class he suggested that a combination of reciprocating engines and exhaust steam turbines might prove suitable. In such vessels running at, say, a 10-knot speed, the number of revolutions must be low, because a certain disc area of propeller and a certain

number of square feet of blade area were necessary in order to avoid excessive slip. It had been found by experiment that the pitch ratio could not be much less than 0.8 without incurring an excessive loss from the skin friction of the blades. On the other hand, to obtain a reasonable economy from the steam turbine, a certain bucket speed was required, and if the revolutions were low, both the diameter and the number of rings of blades must be increased in order to maintain economy. The result was that for a 10-knot speed the number of rows became inordinately great, and the weight and cost became excessive. By fitting reciprocating engines in conjunction with exhaust steam turbines the difficulty could be overcome, with an economy superior to the best tramp steam in existence. The turbine would receive the steam at about 7 pounds absolute, and expand it down to the condenser pressure. The gain effected would be 15 to 20 per cent., or of the same order as that obtained in the advance from the compound to the triple engines.—"Engineering," London.

SUBMARINE BOAT TAKES LONG PLUNGE.

One of the most unique tests ever held at Newport News occurred on January 16, when the Lake submarine boat *Simon Lake X* was given a submersion test in drydock No. 1, at the shipyard of the Newport News Shipbuilding and Dry Dock Co. The craft was floated into the drydock and the gate closed. Her ballast tanks were then filled with water and her hydroplanes set at the proper pitch, after which she was submerged. When near the bottom of the big basin a five-ton emergency weight attached to her keel was dropped from her hull, and with the water still in her ballast tanks the little craft rose to the surface of the water without the slightest hitch. The test was one of the most successful ever given the vessel, and the inventor, Captain Simon Lake, is highly pleased with the craft's behavior.

The emergency weight is carried by the vessel so that in case the other seven ways provided by Inventor Lake to

make the vessel come to the surface of the water fail, the weight can be dropped and the vessel thus given a buoyancy of five tons, which is calculated to cause her to rise to the surface at once.

The *Simon Lake X* is almost completed, and the date for the government test will be fixed in the near future. Inventor Lake denies the reports circulated to the effect that *Simon Lake X* has been sold to Russia, and declares she will be used only in the government test.—"Nautical Gazette."

MARINE ENGINEERS' CONVENTION.

The thirtieth annual convention of the Marine Engineers' Beneficial Association was called to order by National President Frank A. Jones, at the Ebbitt House, Washington, D. C., on Monday morning, January 16, forty-five associations being represented by upwards of one hundred delegates. The sessions of the convention are not open to the public, but much work of interest to the membership was accomplished. It was decided to establish a national organ, and arrangements for its publication will be made by the national officers of the Advisory Board during the coming year.

The election of officers for the ensuing year resulted in the re-election of F. A. Jones, of San Francisco, as President, and of C. W. Robinson, of Washington, D. C., as First Vice President; E. L. Jenkins, of Cleveland, Ohio, Second Vice President; Geo. A. Grubb, of Chicago, Ill., Secretary; Albert L. Jones, of Detroit, Mich., Treasurer; and W. D. Blaicher, of Buffalo, N. Y.; W. F. Yates, of New York; G. F. Keating, of Boston, Mass., as members of the Advisory Board.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The fiftieth meeting of the American Society of Mechanical Engineers, which was also the twenty-fourth annual meeting, was held in New York City on Tuesday to Friday, December 6

to 9, 1904. A strong program of technical papers was considered, a program which dealt almost exclusively with machinery, tools and apparatus, or tests thereof. The discussion of Shop Management and similar general subjects, which has been such a large feature of the last half dozen meetings of the society, was absent.

The official business transacted at the meeting comprised three main items: the election of officers, the discussion of a proposed constitutional amendment, and the reception of two interesting mementoes, the gifts of members.

The ballot for officers resulted in the confirmation of the ticket presented by the nominating committee. The new officers are: President, Mr. John R. Freeman, of Providence, R. I.; Vice-Presidents, Mr. Samuel M. Vauclain, of Philadelphia, Pa., Mr. H. H. Westinghouse, of New York, N. Y., and Mr. Frederick W. Taylor, of Philadelphia, Pa.; Managers, Mr. George M. Brill, of Chicago, Ill., Mr. F. J. Miller, of New York, N. Y., and Mr. R. H. Rice, of Providence, R. I.; Treasurer, Mr. Wm. H. Wiley, of New York, N. Y.

At the opening session of the meeting, on Tuesday evening, December 6, President Ambrose Swasey delivered the presidential address, a brief but suggestive review of a few achievments in wonderful accuracy, under the title, "Some Refinements of Mechanical Science." Immediately following, Mr. C. W. Hunt addressed the society to present, on the behalf of an unnamed donor, a portrait of Professor John E. Sweet, of Syracuse, N. Y. Professor Sweet is one of the founders of the society, and to his activity and influence the success of the society's early years is largely attributed.

At the last session of the meeting Mr. James M. Dodge, of Philadelphia, Pa., presented to the society a bronze bust of Captain John Ericsson, the man who "twice revolutionized the science of naval architecture," as Mr. Hunt's presentation address had phrased it a few days before. The bust is a copy of a plaster bust made in the prime of the great engineer's life, a bust which was acknowledged by him to be an excellent likeness. The plaster bust had never been duplicated or re-

produced in more enduring form until Mr. Dodge had this bronze replica prepared as a gift to the society.—"Engineering News."

EXPOSITION OF MILAN, 1906.

The following is published at the request of the Commission of the Exposition of Milan, 1906.

The Executive Committee, for the purpose of better attaining the object of uniting at the Milan Exhibition all the improvements which the human genius has made, as well in the artistic as in the industrial field, has brought to the notice of the Italian Minister of Agriculture Industry and Commerce, the necessity of formulating special legislative provisions (as has been done before in the case of all previous International Exhibitions) to give protection to everything that will be sent to the Exhibition from abroad.

The legal provisions invoked contemplate the derogation of the articles 50, 64 and 68 of the law on Italian patent rights, etc. These provisions should, for the objects exposed, suspend, first of all, the prohibition of introduction into the Kingdom of objects similar to those protected in the Kingdom, and limit the right to sequester infringements of articles bearing forbidden marks to the sole cases in which the person who provokes the sequestration holds the rights in the same country as the person who is to suffer the sequestration.

Further it should be sought to assimilate the showing of new inventions in the Exhibition to the promotion and utilization of inventions, and interrupt the expiration of patents, etc. Lastly, to the states who do not belong to the International Convention on Industrial Rights, there should be extended a protection to patentable objects exposed.

The Minister of Agriculture, Industry and Commerce has replied that this serious matter has already been taken into consideration.

SHIPS.

UNITED STATES.

The following new vessels were put in commission during the year 1904:

Ohio—*Battleship.*—On October 4th. (For description of vessel and trial see page 1027, Vol. XVI.)

Denver—*Protected Cruiser.*—On May 17th. (For description of vessel and trials see pages 67 and 612, Vol. XVI.)

Des Moines—*Protected Cruiser.*—On March 5th. For description of vessel and trial see page 227, Vol. XVI.)

Tacoma—*Protected Cruiser.*—On January 30th. (For description of vessel and trial see page 1, Vol. XVI.)

Blakely—*Torpedo Boat.*—On December 27th. (See page 1076, Vol. XVI, for description of vessel and trial.)

Nicholson—*Torpedo Boat.*—On January 10th.

Tingey—*Torpedo Boat.*—On April 9th. (See page 50, Vol. XVI for description of vessel and trial.)

The following vessels were launched during the year 1904:

Virginia—*Battleship.*—By Newport News Shipbuilding and Dry Dock Co., Newport News, Va., on April 5th.

Nebraska—*Battleship.*—By Moran Bros. Co., Seattle, Wash., on October 7th.

Georgia—*Battleship.*—By Bath Iron Works, Bath, Me., on October 11th.

New Jersey—*Battleship.*—By the Fore River Ship and Engine Co., Quincy, Mass., on November 10th.

Rhode Island—*Battleship.*—By the Fore River Ship and Engine Co., Quincy, Mass., on May 17th.

Connecticut—*Battleship.*—At the Navy Yard, New York, on September 29th.

Louisiana—*Battleship.*—By the Newport News Ship Building and Dry Dock Co., Newport News, Va., on August 27th.

California—*Armored Cruiser.*—By the Union Iron Works, San Francisco, Cal., on April 28th.

South Dakota—*Armored Cruiser.*—By the Union Iron Works, San Francisco, Cal., on July 22d.

Tennessee—*Armored Cruiser.*—By the William Cramp & Sons Ship and Engine Building Co., Philadelphia, Pa., on December 3d.

Milwaukee—*Protected Cruiser.*—By the Union Iron Works, San Francisco, Cal., on September 10th.

Charleston—*Protected Cruiser.*—By the Newport News Ship Building and Dry Dock Co., Newport News, Va., on January 23d.

Dubuque—*Gunboat.*—By the Gas Engine and Power Company and Charles L. Seabury & Co., Morris Heights, New York, N. Y., on August 15th.

Paducah—*Gunboat.*—By the Gas Engine and Power Company, and Charles L. Seabury Co., New York, N. Y., on October 11th.

New Hampshire, North Carolina and **Montana.**—The New York Shipbuilding Company has secured the contract for the building of the battleship *New Hampshire*, authorized by the Act of Congress approved April 27, 1904.

The contract for the two armored cruisers, *North Carolina* and *Montana*, provided for in this same Act, has been awarded to the Newport News Shipbuilding and Dry Dock Company.

A general description of these three vessels appears on page 1255, No. 4, Vol. XVI, of the JOURNAL.

Colorado—*Commissioned.*—The armored cruiser *Colorado* was placed in commission at the League Island Navy Yard on January 19, 1905. (For description of vessel and trials see page 1118, Vol. XVI, of the JOURNAL.)

Galveston—*Commissioned.*—The protected cruiser *Galveston* was commissioned at the Navy Yard, Norfolk, on February 15, 1905.

West Virginia—*Commissioned.*—The armored cruiser *West Virginia* was commissioned on February 24, 1905, at New-

port News, Virginia. (For description of vessel and trials see page 59 of this issue.)

Submarine Boats.—The Electric Boat Company, of Bayonne, N. J., has recently secured from the Navy Department a contract to build two submarine torpedo boats of the Holland type.

These boats, which are to be of the latest design, will be constructed at the works of Fall River Ship and Engine Building Co., Quincy, Mass.

Newport—*Accident to.*—While *en route* to Sanchez, Santo Domingo, on January 30th, the U. S. S. *Newport* lost her propeller, due to breaking of the tail shaft. The accident occurred while about 400 miles southeast of Cape Henry, to which point the vessel proceeded under sail, arriving on February 9th, very heavy weather being experienced during entire trip.

The vessel has not yet been docked, and cause of accident is not at present known.

ENGLAND.

During the year 1904 the following vessels were commissioned for service:

Battleships.—*Cornwallis* on February 9th; *Queen*, April 7th; *Prince of Wales*, May 18th; *Swiftsure* and *Triumph*, June 21st.

Armored Cruisers.—*Euryalus*, January 5th; *Essex*, March 27th; *Lancaster*, April 5th; *Suffolk*, May 21st; *Cornwall*, and *Cumberland*, December 1st.

Protected Cruiser.—*Topaze*, December 6th.

In addition to the above the sloop *Cadmus* was commissioned on April 13th, and also eighteen torpedo-boat destroyers during the year.

The battleships *King Edward VII*, *Dominion* and *Commonwealth* were completed but not commissioned; other vessels completed were the protected cruisers *Amethyst*, *Diamond* and *Sapphire.*

Britannia—*Launch of.*—At Portsmouth, December 10, 1904, the battleship *Britannia*, of the *King Edward VII* class, was

launched. Her principal dimensions are as follows: Length, between perpendiculars, 425 feet; beam, 78 feet; mean draught, 26 feet 9 inches; displacement, 16,400 tons. The following details are from "The Steamship."

The armament consists of the following guns: Four 12-inch breech-loading guns in barbettes forward and aft; four 9.2-inch breech-loading guns in barbettes on upper deck; ten 6-inch breech-loading 50-caliber guns of latest design in an armored battery on the main deck; twelve 12-pounder, 18-cwt., quick-firing guns on upper and shelter decks; two 12-pounder, 8-cwt., quick-firing guns on shelter deck for boat and field service; fourteen 3-pounder, quick-firing guns, three of which are also for boat service; two 0.303-inch Maxims, which are also intended for boat or field service. In addition, there are four submerged torpedo tubes, for which eighteen 18-inch torpedoes will be carried, besides six 14-inch torpedoes for the boats. An armored belt, varying in thickness from 9 to 2 inches and about 14 feet in width, extending to about 5½ feet below water line, will be worked for protection. The battery for the 6-inch guns will be protected by 7-inch armor, the guns being isolated by protective screens 2 inches in thickness. The 12 and 9.2-inch barbettes will be protected by armor varying in thickness from 12 to 4 inches. The ship will be propelled by twin-screws, each actuated by an independent set of vertical, triple-expansion engines, each with one high-pressure, one intermediate and two low-pressure cylinders of the collective power of 9,000 horsepower, giving an aggregate indicated power for both engines of 18,000 horsepower, the boilers being loaded to 210 pounds per square inch, the steam being reduced to a pressure of 205 pounds per square inch at the engines. With this power a speed of about 18.5 knots is anticipated. The boilers are of two types, these being three cylindrical and eighteen water-tube of the Babcock & Wilcox type. The former are arranged in one boiler room and the latter in three boiler rooms. The engines and boilers are being built by Messrs. Humphrys, Tennant & Co. The amount of coal car-

ried at the normal draught is 950 tons, but stowage will be provided for about double that quantity.

Hindustan.—This first-class battleship has just completed her official trials. The *Hindustan*, the third of the modern British battleships built by Messrs. John Brown & Co., at Clydebank, is of the *King Edward VII* class, with a total length of 425 feet, and a beam and draught of 78 feet and 26 feet 9 inches, respectively. Her displacement is 16,350 tons, and her engines, also constructed by the builders of the vessel, are designed to indicate 18,000 horsepower, giving a speed of 18.5 knots. She is fitted with eighteen boilers of the Babcock & Wilcox type, and three of the cylindrical type.

Squirrel—*Launch of.*—Messrs. Workman, Clark & Co., Limited, Belfast, launched on December 21, 1904, the *Squirrel*, a coast-guard cruiser for service in the English Channel. The engines and boilers have been constructed by the builders at their Queen's road Works, and consist of a set of triple-expansion engines, supplied with steam from multitubular boilers working at a pressure of 155 pounds per square inch.

Argus—*Launch of.*—The 400-ton coast-guard cruiser *Argus* was launched by Bow, McLean & Co., Paisley, on December 6, 1904.

The *Argus* will join the fleet reserve; she was launched with steam up and proceeded immediately down the river for a series of trials.

Her battery consists of two 6-pounder, quick-firing guns.

Chelmer—*Launch of.*—The torpedo-boat destroyer *Chelmer* was launched by Thornycroft & Co. on December 8, 1904. She will have a speed of 25½ knots.

Wear—*Launch of.*—The new torpedo-boat destroyer *Wear* was launched on Saturday, the 21st ultimo, from the shipbuilding yard of Messrs. Palmers' Shipbuilding Company, Jarrow-on-Tyne. She is the second of three similar vessels which the firm is constructing for the Admiralty. The first of the three, the *Ure*, is nearing completion, and the third, the *Swale*, is on the stocks. They are of a stronger build than the earlier type. The *Wear* is 225 feet long and 23 feet 6

inches broad. Her engines, fitted with Palmers' system of forced lubrication, will indicate 7,000 horsepower. She will carry two 12-pounder and five 6-pounder guns.—"Engineering," London.

Submarines—*Launch of.*—Two submarine torpedo boats of the "*B*" type were launched at the shipyard of Messrs. Vickers Sons & Maxim on January 23d.

Destroyers.—The new "River" class of low-speed torpedo-boat destroyers are to be followed by a type of destroyer able to outpace anything afloat. The Admiralty are credited with the wish to add to the Navy torpedo-boat destroyers able to steam from 33 to 34 knots, and, if this report be true, it is certain that the hostile criticism leveled against the 25-knot "River" class has been seriously considered at Whitehall. As has been pointed out before in these columns, it was not fair to condemn lightly-built swift boats merely because one or two of them, undoubtedly weak in structure, happened to be unable to withstand the fury of the sea. That it is not impossible to build fast destroyers with good sea-keeping powers Messrs. Yarrow or Thornycroft could easily prove. Safety must not be sacrificed to speed; but speed, it must be remembered, is at once the principal part of the defensive as well as offensive powers of this type of vessels. The projected 33-knot boats may be driven by reciprocating or turbine engines, and may burn oil or coal; but whatever combination is adopted the Admiralty are said to be determined to leave no stone unturned to get the fastest and safest boats of the class that British builders can turn out. If such destroyers were built, they must be "nursed" if they are to retain their speed, and must not be used as messengers in peace time on any and every occasion.—"The Marine Engineer," London.

Machinery for Cruisers.—The British Admiralty has placed orders for the machinery of three armored cruisers which are to be constructed in the Royal Dockyards. One of the ships will be engined by Scott's Shipbuilding and Engineering Co., of Greenock; another by Harland & Wolff, Belfast, and the third by Humphrys, Tennant & Co., London. These cruisers,

to be known as the *Minotaur* class, are of 14,600 tons displacement, and in respect of guns and armor will be the most powerful cruisers in the British Navy, having four 9.2-inch guns and ten of 7.5-inch caliber. The speed will be 23 knots, to be attained by machinery of 27,000 indicated horsepower. There will be four cylinders in each engine, although the triple-compound system will be still adopted. The diameter of the cylinders is 40⅝ inches in the case of the high-pressure cylinder, 65½ inches in the intermediate and 74⅝ inches for each of the low-pressure cylinders, the stroke in all cases being 48 inches. The power is to be maintained with the engines making 125 revolutions. Babcock & Wilcox and Yarrow water-tube boilers will be adopted.—"Nautical Gazette."

New Scouts for the British Navy.—The performance of H. M. S. *Sentinel*, the first of the new scouts for the King's Navy, adds one more to the many successes in recent years of the Vickers Company; the vessel attained a speed considerably exceeding that of any vessel, either of naval or mercantile type, other than torpedo craft, and practically equal even to the rate reached at full power by the later torpedo-boat destroyers. The result indicates not only a very fine form of hull—of which a suggestion was given by the photographs of the vessel on the ways, which we reproduced on page 608 of Vol. LXXVII—but a high efficiency in each of the respective units of machinery—boilers, engines, and propellers. The actual speed realized was 25.24 knots, when the displacement of the vessel was 2,920 tons, and the power developed just over 17,500 indicated horsepower. Such a power in a vessel of this tonnage, and of a length of only 360 feet, has only become possible by the great advances in mechanical engineering.

Before referring in detail to the trials, some indication may be given as to the evolution and utility of the scout class. Effective reconnaissance work for any war fleet can best be done by high-speed well-armed cruisers, but the steady advance in size and fighting equipment of such vessels has so increased their cost that even a nation of great financial resources must consider whether it is not possible to have some of the subsi-

diary duties, especially those involving numbers, performed by special and cheaper craft. The problem set is practically that met with in every-day commerce, and solved by the utilisation of telephones and messenger boys, so that the heads of the departments—the great thinking machines of establishments—may be able to concentrate their energy upon the most remunerative work.

The battleship represents the chief element of force in a war fleet; it has now been developed to a very high state of efficiency, which is only another way of saying that it costs an enormous sum of money. Britain is now paying over £1,400,000 for her ships-of-the-line; America, quite £1,500,000; and Japan proposes to lay down a ship the cost of which, with the armament—including four 12-inch, twelve 10-inch and twelve 4.7-inch guns—will involve still greater expenditure. The British ratepayer may as well realize now as later that there can be no finality in this matter, and when such a high authority on naval matters as Mr. Albert Vickers foreshadows the building of high-speed ships-of-the-line, with twelve 12-inch guns, it only becomes a matter of months when such experienced judgment will be carried into effect by the British Admiralty. We must therefore look forward to the building in the near future of battleships of the type indicated by Mr. Vickers, costing £2,000,000. The same advance in power and cost has taken place in respect of armored cruisers, and today, owing to the necessity of high speed in combination with effective broadside protection and high-power guns—and plenty of them—we are closely approaching a cost of £1,300,000 sterling. That being so, the question was tackled by responsible strategists as to whether relief could not be obtained by the building of special vessels for reconnaissance work, so as to conserve the energy of the cruisers until the enemy's fleet was discovered, when the armored cruisers might make a collective reconnaissance in force, piercing the enemy's screen effectually, and ascertaining the extent of the opposing fleet.

Such ordinary scouting work, being primarily intended to

ascertain the position rather than the strength of the enemy, does not require the exercise of force to any great extent; and if four such scouts can be built for the price of one armored cruiser, as is now the case, the result is that the Admiral has four pairs of eyes, instead of one, to direct the action of the chief elements of force of his fleet. The Admiralty therefore decided to have a new type of cruiser, solely for scouting duty, and invited designs from the various ship-building firms throughout the country, laying down certain general conditions. Some firms, including the Vickers Company, suggested a hull of sound structural strength, so that a high speed might be realized under heavy weather conditions. This is an indispensable quality for reliable reconnaissance work. Others, however, submitted designs of lighter craft; but in the end all the vessels were brought up to the higher displacement. Eight have been ordered—two from each of four firms—Sir W. G. Armstrong, Whitworth & Co., Limited; Cammell, Laird & Co., Limited; the Fairfield Company, Limited; and Vickers Sons & Maxim, Limited; and the type has awakened very considerable interest.

It is easy to find fault with particular designs, because each student of tactics addresses the subject from the point of view with which he is either most familiar or most in sympathy. But it should never be forgotten that compromise is essential. In these scouts speed was the first consideration, and 25 knots is only a satisfactory *minimum* rate, as opposing armored cruisers may have a trial speed of 23 knots. We have indicated that it was not intended that the vessels should exercise force; the armament has been determined more with the idea of combating torpedo craft when used for scouting than for facing up to any large vessel. The scouts therefore have ten 12-pounder guns and eight 3-pounder guns, with two tubes on deck for launching 18-inch torpedoes. This is the armament set down by the Admiralty in their invitations for designs. Some would have had a more powerful armament, but any guns heavier than those fitted, yet too weak to combat a large cruiser of the enemy, would have been a waste of weight; it

is is better far that the vessels should be able to run away for protection within the screen of their own squadron.

The question also has been raised as to whether these vessels have sufficient coal endurance. The details of size, load and speed must enter into this calculation. The addition of 100 tons to the bunker capacity of any ship involves a disproportionately large addition to the weight of the hull, which, again, necessitates increased engine power for a given speed. The scouts may seldom require to work at any great distance from the screen of the main fleet. High speed is required primarily for evading the enemy when discovered and also for informing the admiral of his location. Even this latter matter may not always involve the expenditure of coal necessary to attain high speed, because it would be idle for a scout to report the location of a squadron at any given time unless that time happened to be the moment when the admiral wished to engage it. Consequently the scout will require to hang on to the fleet while utilizing its wireless telegraphy to acquaint the admiral in command as to the situation. A scout may be used for dispatch duty, and the Admiralty have probably decided upon the radius of action with due regard to the fulfillment of such function, which demands a high speed. There is always the last resort of coaling from fleet colliers.

But the important point has been speed, as to the necessity for which all are agreed. It is not always realized by critics how much power high speed involves; every extra knot means an enormous addition to power. This was clearly brought out by the progressive speed trials which the Vickers Company carried out for their own information, and to add to that scientific data which enable them to predict with absolute precision results of a high order from any given set of conditions. It was found that while a speed of 19 knots was realized with a quarter of the full power, a corresponding addition to power only added then 3¾ knots; the third addition, of the same proportion of the total, increased the speed by 1½ knots, and the final fourth of the power added only about 1 knot. In other words, the increase from 24 to 25 knots cost as much in

power as the first 19 knots. It is thus easy to understand that much could be done in the way of increasing armament, protection, or coal capacity, if 1 knot less speed were acceptable, since it would then be possible to reduce the weight of machinery by quite 20 per cent. Having determined that speed is the primary consideration, other elements in design must take a secondary place. In thus referring to the criticism of the type, we must not be assumed as adopting an apologetic tone, because, in view of the conditions which the designers were required to meet, the results in the case of the *Sentinel* are eminently satisfactory.

In the matter of protection the respective designers had a free hand; in two cases an arched deck of about 1½ inches in thickness is adopted; in two others the machinery is protected on the water line by broadside armor 2 inches thick. Here again the question arises as to excess of protection beyond the maximum required in view of the duty to be discharged. We do not say that the broadside armor is more efficient than the protected deck, because, with the curvature, the 1½-inch becomes more effective against lateral attack than with right-angle direct impact. Much can be said in favor of both systems. The real question is the efficacy of the protection afforded per unit of weight involved, and this is only a question which can be effectually determined in action. It must always be remembered that it will be the duty of the scout to run away. The protective deck certainly adds very materially to the strength of the ship, both longitudinally and transversely, so that it is an important element in the sea-worthiness of the ship. The question of the endurance of the machinery under adverse weather conditions in such light craft is an important one, and the more substantial the scantlings, and the more ample the bearings, the more likely is the ship to maintain her speed in heavy weather. The Vickers' design stands first in this respect. One of the firms has adopted torpedo-boat destroyer engines, two sets being fitted on each shaft, to run at 250 revolutions per minute, instead of 200 at full power, as in the *Sentinel.*

The *Sentinel* is a vessel 360 feet between perpendiculars, with a beam of 40 feet, and, with all her sea stores and ammunition on board, her displacement is 2,920 tons. She is built with a high forecastle, but with a low freeboard amidships and aft, so that she will not be readily seen by the enemy. At the same time she has a very high bridge, so that she can watch the enemy's ship when hull down, so far as their vision is concerned. She has a foremast for signaling purposes, with a gaff for wireless telegraphy, as well as a truck semaphore. The machinery consists of two sets of four-cylinder triple-compound engines, well balanced. The cylinders are carried on cast-iron A columns at the back, and steel columns at the front, with a cast-steel bed plate. The propellers have three detachable blades, and, with the boss, are of bronze.

The contract trials differed from those specified for other ships of the Navy, and were much more severe. In the first place, the vessels of the class are required to steam for 96 hours at a cruising speed of between 10 and 12 knots; the coal consumption per knot on the latter half of this trial is to form the basis for determining the load to be carried in the bunkers on the full-power trial—when the vessel must take sufficient fuel to enable her to steam for 1,500 sea miles. The duration of this trial, and the acceptance of the last half, made it certain that, so far as the boilers—fire-grates, tubes, &c.—were concerned, the most adverse conditions as regards long-distance steaming would be realized. The *Sentinel* on this trial attained a high economy, and for the cruising speed it was found that each ton of coal was sufficient to propel the ship for 11 sea miles. This included the running of all the auxiliary machinery by night and day, and also the make up of all the feed water that was lost. For three-quarters of this trial the vessel experienced very severe weather, being driven for long periods in the teeth of a gale, so that the economy attained is the more remarkable.

The full-power trial took place on Friday, January 27, and followed upon the progressive-speed and other experimental

runs to which we have referred; but it should be stated at once that these experimental runs were not involved by any degree of uncertainty as to elements of design, as on the first preliminary trial a speed of 25 knots was realized under the conditions which were evolved in the original design. In fact, throughout there has been a very remarkable assimilation between anticipated and realized results. On the full-power trial it was stipulated that the vessel should make six runs over the measured mile at Skelmorlie within a period of 1½ hours, and that on the subsequent 6½ hours the revolutions of the engines should correspond with those required on the measured mile for the guaranteed speed of 25 knots. The runs on the measured distance were made well within the period, notwithstanding the necessity of making wide circles at both ends of the mile, and of avoiding the traffic on the river. The six runs gave remarkably uniform results: the first run on the slack tide was made in 2 minutes 22.2 seconds; the second, also on the slack tide, in 2 minutes 22.8 seconds; the third, with the tide, in 2 minutes 21.2 seconds; the fourth, against the tide, in 2 minutes 24.4 seconds; the fifth, again with the tide, in 2 minutes 21.6 seconds; and the sixth, also in 2 minutes 24.4 seconds. It will thus be seen that the variation between the two runs on the slack tide was only three-fifths of a second; between the two runs with the tide, two-fifths of a second; the two runs against the tide being made in exactly the same time. The variations in the revolutions of the engines during this period were within practically one unit, and the mean number per minute was 206.2, while the power was just over 17,500. At the conclusion of this trial the vessel continued for 6½ hours at this power, and everything worked most satisfactorily. The Vickers boilers gave good results; they were, of course, worked under the closed-stokehold system, with an air pressure of 2½ to 2¾ inches of water. The water losses per 1,000 horsepower per 24 hours, due to all purposes, was about 3 tons, and the coal consumption was 2.1 pounds per horsepower per hour. These results show that not only from the point of view of speed, but of engine efficiency,

the *Sentinel* marks a very high standard in naval construction.—"Engineering," London.

Submarine A-5—*Explosion on Board.*—In the harbor of Queenstown, Ireland, on February 16, an explosion occurred on board the submarine boat *A-5*, resulting in the death of four men and injury of fourteen others.

The cause of the explosion has not as yet been determined, but is thought to have been due to the gasoline on board.

Immediately after the explosion the vessel caught fire. A volunteer crew from the torpedo gunboat *Hazard* was sent on board, and almost immediately upon their arrival a second explosion occurred, blowing several overboard and injuring a number.

The injuries to the vessel are reported as slight. The *A-5* is a new vessel, having left the builders' yard on February 11th.

FRANCE.

The vessels completed for the French Navy during the year 1904, consisted of four armored cruisers, the *Gloire*, *Condé*, *Dupetit Thouars* and *Léon Gambetta*, also about eighteen submarines and five torpedo-boat destroyers.

Torpedo Boat Number 293.—The following data is from London "Engineering:" The boat is 130 feet long, 14 feet beam and 94.6 tons displacement, with 19.5 tons load—in fact, is as near like the reciprocating engine-propelled torpedo boats of the same type as was possible to build, modified only to suit the turbine machinery. Two Normand water-tube boilers supply steam at 250 pounds pressure. The hull was built by Augustus Normand & Co., and the engines by Parsons Marine Steam Turbine Company. A high-pressure turbine is fitted on the port wing shaft, and exhausts into the intermediate-pressure, driving the starboard wing shaft, which in turn exhausts into the low-pressure turbine on the center shaft. This arrangement is only for speed above 17 knots; for all lower speeds an additional high-pressure turbine is employed, and the ordinary high-pressure, which receives its exhaust, becomes the first

intermediate. This cruising turbine, as it is called, is placed on the center shaft and coupled to the low-pressure turbine, and, when not required, steam is simply shut off from it and it revolves idly in a vacuum. The auxiliaries include two Normand condensers, Weir main and auxiliary feed pumps, air pumps driven by a reduction gearing from center turbine shaft, Normand feed heater and filter, etc. Reversing is accomplished by a set of reversing blades fitted at the aft end of the low-pressure turbine.

The eight-hour official consumption trial, at 14 knots, resulted in boilers taking 683 pounds of coal per hour, and the two-hours' continuous fuel speed runs gave an average of 26.205 knots and 26.663 maximum. An analysis of the trials compares favorably with the reciprocating-engined torpedo boats, for, with the cruising turbine, low coal consumption was attained such as not heretofore attained with turbines. In some torpedo boats the reciprocating engine has been fitted for cruising speeds with turbines for full power, which double arrangement is not altogether to be recommended.

Du Temple-Guyot Boilers.—The boilers of the two armored cruisers *Jules Ferry* and *Jules Michelet* will be of the *Du Temple-Guyot* type, with small tubes, but the majority of the other vessels under construction will be fitted with Niclausse or Belleville steam generators with large tubes.

Scouts.—The next program of construction is expected to contain particulars of a new class of protected cruiser, approximating to the scout type of the British Navy. They are to be of 3,000 tons displacement, with 26 knots speed, and the first batch will probably be laid down in the course of this year.

—"Page's Weekly."

GERMANY.

The following vessels were commissioned during the year 1904:

Battleships.—*Braunschweig* and *Elsass.*

Protected Cruisers.—*Hamberg*, *Bremen* and *Berlin.*

Six torpedo-boat destroyers have also been completed.

München and Undine—*Launch of.*—The two protected cruisers, *München* and *Undine* were launched at Wilhemshaven on January 11th.

Notes.—"Ueberall" reports that the German battleship *Braunschweig* in her recent trials made an average of 18.43 knots during a five-hours' run. Her contract speed is 18 knots. In an endurance trial of eleven hours her engines developed an average of 11,588 horsepower. The average speed is not given, but with her engines developing 10,270 horsepower her speed was 16.41 knots, and 17.497 knots with 12,730 horsepower. The replacing of the rudder, which the German battleship *Elsass* lost on her trials, will take some time. The *Barbarossa*, of the *Kaiser* class, will be commissioned to take her place while she is in dock. The *Barbarossa* also lost her rudder in consequence of the breaking of her stern-post, and has been in dock under repair. Both vessels were built by the Schichau firm. At the trials of the German coast-defence ship *Aegir* after her reconstruction, the highest speed she attained was 15.27 knots. The results of the trials of the battleship *Schwaben* are still not published, but it is still hoped that she will be able to make 18 knots in deep water. The armored cruiser *Friedrich Karl* in a twenty-four hours' run averaged about 18.7 knots, her engines developing an average of 17,759 horsepower. The sea ran high and there was a strong wind against her. Later she made 20.5 knots in a six-hours' run, which still leaves something to be desired. The protected cruiser *Bremen* made 23.288 knots on the measured mile in deep water. In an endurance trial of ninety-three hours her engines averaged 124 revolutions. The speed is not given, but with 120.55 revolutions her speed was 20.327 knots, and with 135.88 revolutions, 22.466 knots. In a long run, therefore, she can be depended upon to maintain a speed of from 20.5 to 21 knots; but it is a pity she cannot carry more coal. The sea-going torpedo boat *S-123* made 28.3 knots on her trials. The same rate of speed was reached by *S-125*, which is the boat fitted with turbines, and built for a 27-knot speed. The armored cruiser *Prinz Adalbert*, while running

under full steam with forced draft, burst the high-pressure cylinder of one of her engines. A new cylinder will have to be put in.—"Engineering," London.

Deutschland, *Launch of.*—The latest addition to the battleships of the German Navy is the *Deutschland*, launched from the covered slips of the Germania yard at Kiel, on November 19th. Her principal dimensions are the same as those of the *Braunschweig* class, of which the *Braunschweig*, only recently put into commission, and the *Hessen*, now almost completed, have been built by Messrs. Krupp, at the same yard. The length of these vessels between perpendiculars is 398 feet 6 inches; the maximum breadth, 72 feet 9 inches; and the draught, 25 feet 1 inch; their displacement being 13,000 tons. The armor belt is 9 inches thick amidships and 4 inches thick at the ends. The deck armor is 3 inches thick, and slopes at the sides to a junction with the lower edge of the belt. The side armor of the citadel and battery-deck casemate is, respectively, 5½ inches and 6 inches thick, the casemate being covered in by a protective deck. There are two conning towers, the one at the fore being protected by 12-inch armor and the aft one by 5½-inch armor.

The main armament consists of four 11-inch guns mounted in a pair of turrets fore and aft, and protected by 11-inch armor. In the central casemate are ten 6.7-inch guns, and four more guns of the same caliber are contained in separate casemates. There are twenty-two 3.5-inch quick-firers mounted on top of the casemates. The fighting tops contain four automatic machine guns of 1.5-inch bore, for protection against the attacks of torpedo boats, and four other machine guns of 0.3 inch. Six 18-inch submerged torpedo tubes are fitted—four broadside, one at the bow, and one at the stern of the vessel.

The *Deutschland* is propelled by three sets of triple-expansion engines, aggregating 16,000 indicated horsepower, and expected to give a speed of 18 knots. Steam is supplied by six cylindrical boilers and eight water-tube boilers, the latter of the Schulz-Thornycroft type. The normal coal-carrying

capacity is 700 tons, but 900 tons more can be stored in the reserve bunkers. The double-bottom compartments are fitted for the carriage of 200 tons of tar oil, which is also intended as fuel.

The vessel will carry the Admiral's flag, and will be manned by 35 officers, 35 warrant officers, 16 ensigns and a crew of 650 men.—"Engineering," London.

ITALY.

During 1904 the battleship *Benedetto Brin* and two destroyers were commissioned for service.

Delfino.—The Italian submarine boat *Delfino* is built of steel plates 1.2 inches in thickness. She is cigar-shaped, her length being 78.4 feet and her beam 9.5 feet. Her displacement varies, according to the extent of her submersion, from 95 to 107 tons. Her engines are worked solely by electricity furnished by 300 accumulators. She has three propellers—one aft for movement ahead or astern, and the other two above for the work of submersion and emersion. The little turret is glazed so that a lookout may be maintained when the boat is submerged. Her sole armament consists of two torpedo tubes forward. Her oxygen supply is not sufficient for officers and crew more than twelve in number.—"Scientific American."

MEXICO.

Bravo and Moreoa.—There were recently delivered to the Mexican government two twin-screw gunboats, the *Bravo* and *Moreoa*, built at the Oderos shipyard at Sestri Ponente, near Genoa. The general dimensions are as follows: Length, 250 feet; beam, 34 feet; depth, 14 feet; displacement, 1,280 tons; designed speed, 17 knots. The vessels are very light draught, for navigating the shallow rivers of the Mexican coast, while, at the same time, the bunker capacity is sufficient to carry the vessel 5,000 miles at a speed of 10 knots. The propelling machinery consists of two sets of three-cylinder, direct-acting, triple-expansion engines of 2,600 I.H.P. Steam is supplied by two water-tube boilers.

There are two 4-inch R.F. guns of Bethlehem make, which fire directly ahead and astern respectively, and have a total arc of fire of 150 degrees; four 2¼-inch R.F.G., Schacidercant type, are fitted on broadside and one on the bridge. The 4-inch guns are supplied with ammunition by electrical hoists capable of delivering 24 charges per minute. Electrical hoists are provided for the other guns also. The crew will be composed of 26 officers and 90 men, and in addition quarters are provided on board for about 270 troops. There are six boats, two of which are steam launches, for quickly disembarking the troops. Fresh air is supplied to the quarters by electric fans, and a large refrigerating plant is installed. The *Bravo* will proceed direct to Mexico as soon as she has completed her trial trip.—"Marine Engineering."

THE NETHERLANDS.

The Dutch Navy budget for 1905 provides for the completion of the battleship *Tromp*, the four torpedo boats, *G-1–4* (of which *G-1* was launched on December 17th and *G-2* on December 28th, by the Schelde Company), and one submarine. A new battleship, "*E*," is to be laid down and four more torpedo boats, sisters to *G-1*, are to be begun. The torpedo boats *Tangka*, *Wajang* and *Semeroe* have made 25.6, 24.7 and 24.6 knots respectively on trial.—"Page's Weekly."

RUSSIA.

During the year 1904 the following vessels were completed and put into service:

Battleships.—*Kniaz Suvaroff*, *Orel* and *Borodino*.

Protected Cruisers.—*Izumrud*, *Jemtchug* and *Oleg*.

Naval Program.—"The Emperor has sanctioned the expenditure of £160,000,000 for rebuilding the Russian Navy." In these bald words the St. Petersburg correspondents announced the new scheme for the replacing of the squadrons which Russia has lost in the war. The program is to cover ten years, and many of the vessels will be built abroad. The building program is to consist of eight battleships of the

Kniaz Suvaroff type, eight of the *Andrei Pervosvannui* class, six armored cruisers, twelve protected cruisers, fifty destroyers, and one hundred torpedo boats.

The Third Pacific Squadron, which is fitting out in great haste at Libau, will take practically every remnant of the Russian fleet from European waters, with the exception of the Black Sea Fleet, which is penned up behind the Dardanelles. Whether the squadron under Admiral Mebagatoff will be ready to start in another fortnight is doubtful, but urgent commands have been issued for it to do so.—"Page's Weekly."

SWEDEN.

Naval Program.—The Naval Program of 1901, which was to have been completed by next year, has fallen so much in arrears that an increased grant has been asked for for 1905, in order that the program may be completed in 1907. The following is the proposed allotment of this grant. The sums asked for are as follows: For completing the ironclad *Oskar II*, £140,100; first instalment new ironclad of *Fylgia* type, £123.000 (total cost, £385,700); completion of torpedo-boat destroyer, £33,400; two torpedo-boat destroyers, £133,500; first instalment five large torpedo boats, £55,100; nine small torpedo boats, £99,100; training vessel, £11,600; reconstruction of *Loke*, £29,800; ditto of *Hildur*, *Bjorn* and *Gerda*, £28,050; three guard boats, £14,100.—"Page's Weekly."

MISCELLANEOUS.

Dredge St. Johns.—The sea-going suction dredge *St. Johns*, one of two vessels being built for the U. S. Engineer Corps, has recently been given a successful trial at sea.

These vessels are 200 feet long, 40 feet beam, with a depth of 23 feet 2 inches; they are self-propelling, with wooden hulls. The engines are of the vertical, inverted, compound type and develop about 1,200 indicated horsepower. The boilers, two in number, are the ordinary Scotch type. The pumping machinery on each vessel consists of two centrifugal pumps driven by a vertical, inverted, compound engine of about

700 horsepower. The vessels have in addition the usual auxiliary machinery. The suction pipes are 18 inches diameter (swiveling amidship), and are constructed so that they can be lowered or inclined at the free ends where heavy scraper nozzles are attached. These dredge the bottom of the harbor, and sand is pumped up by means of powerful centrifugal sand pumps, which discharge the heavier material into binns constructed in the hold of the vessels. These binns have a capacity of 1,600 tons, and can be filled in about forty-five minutes. When under way the suction pipes are drawn up and the vessel proceeds to sea, where the sand is discharged through numerous sluices in the bottom of the hull.

Hydraŭlic Suction Dredge.—The Polson Iron Works, Toronto, Ont., is building a hydraulic suction dredge for the Dominion government, which is intended for service on the St. Lawrence channel between Montreal and Quebec. The dredge is somewhat similar to the *J. Israel Tarte*, built by the Polson Iron Works in 1902. The principal dimensions are: Length over all, 127 feet; breadth, 32 feet; depth at side, 9 feet; draught 5 feet. The hull will be of scow model, with square bow and rake stern, for the purpose of towing easily. It is to be constructed of mild steel, divided into bulkheads, and fitted with bunkers to have a capacity of 100 tons of coal. The main deck will be of 3 by 4-inch British Columbia pine, the upper deck of 2-inch British Columbia pine, and there will also be a light shade deck over the hoisting engine. A cabin for officers and crew will be provided; it will be steam heated. Two boats are also to be supplied with the dredge.

The machinery will consist of a direct-acting, inverted, triple-compound, three-crank, surface-condensing engine, having cylinders 14, 22 and 36 inches in diameter by 21-inch stroke, and built for a working pressure of 160 pounds a square inch, and is calculated to develop 600 I.H.P. when running at 190 revolutions a minute. The main dredging pump will be a centrifugal one, with the suction and discharge pipes 24 inches in diameter; and the feed and bilge pumps will consist of two independent horizontal, duplex,

outside-packed plunger pumps 7¼ by 4½ by 10 inches. The hoisting engine for raising and lowering the suction pipe and swinging the boom will be located on the main deck forward, and will be a 10 by 12-inch, two-cylinder, double-acting, independent-type engine, with link motion to allow operation in either direction. The steel boom for raising and lowering the suction pipe will be located at the suction end of the dredge, and will be about 65 feet in length. The suction pipe will have an internal diameter of 24 inches, and will be fitted with a cutter head at the outer end. To excavate the material there will be a rotary steel cutter. The steel head of this will be of suitable shape, and will have attached to it a renewable steel block of such a shape that it will convey the material taken from the bed of the river into the pipe. The outside diameter of the head is to be large enough to enclose the whole of the mouth of the pipe. This head will be driven by a steel shaft carriad along the whole length of the pipe, and receiving its power from a separate engine, by suitable steel gearing. The engine to supply this power will be a two-cylinder, double-acting horizontal engine, 12 by 12-inch stroke, arranged to run in one direction only. The discharge pipe will also be 24 inches in diameter, and will be arranged for discharging the material into scows. The capstans will be operated by two 6 by 8-inch double-acting engines, which are to be located on the main deck forward of the hoisting engine. Steam will be supplied to the various engines by two marine return-tubular boilers, allowed a working pressure of 160 pounds to the square inch. They will be 12 by 12 feet 6 inches, and will have three furnaces, each 35 inches in diameter, and a grate surface in each boiler of 48 square feet. There will be two smoke stacks, each 42 feet in height from center of boiler.—"Marine Review."

Murikiku.—Messrs. William Simons and Co., Ltd., Renfrew, have just launched, complete with steam up and ready for work, a very powerful dredging vessel of their latest design. The boat is named the *Murikiku*, and she has been built to the order of the Agent General for New Zealand. Besides being

fitted with a special set of buckets for dredging rocky ground, the vessel is fitted with a sand-suction pump. The buckets as well as the suction pipe are made to dredge to a depth of forty feet. The hopper is arranged in such a manner that the dredgings can be relifted from the hopper and discharged over the side by a special patent arrangement of the builders, and delivered ashore through a long line of floating pipe for land reclamation, or into barges moored at the side of the dredger. Ordinary hinged doors are also fitted to the vessel's own hopper, so that the material can be deposited at sea when required. The machinery consists of two sets of triple-expansion engines and two cylindrical boilers of 160 pounds working pressure.—" Page's Weekly."

Ice-Breaking Steamer.—The second of the ice-breaking steamers ordered by the Dominion government for the St. Lawrence, has reached Quebec. She was built in Scotland, the principal dimensions being: Length, 245 feet; breadth, 40.5 feet; depth, 18 feet, with a gross tonnage of about 1,350 tons. The vessel is specially strengthened in order to resist pressure, the shell plating at bows and in other parts being of double thickness, with intermediate frames extending fore and aft. The keel, stem, stern post, propeller brackets and rudder are extra strong and heavy, and made of nickel-steel. On the stern post a cast-steel knife is fitted to break ice when working astern, and to protect the rudder. She is propelled by twin screws, and is expected to develop a high rate of speed.—" Nautical Gazette."

Turbine Steamer.—The fleet of nine steamers which the Belgian government maintains for the cross-Channel service is to be increased by the addition of a turbine steamer with a speed of 23 knots. It is said that Belgium intends to replace gradually all the old steamers of a speed of 19 knots by turbine steamers similar to that to be introduced shortly.

Fire and Salvage Float.—A new type of combined fire and salvage float has been constructed for use on the Manchester Ship Canal. The craft is of great power for both the functions for which it has been designed. For fire-extinguishing

work the vessel carries three large monitors, each capable of throwing a solid 2½-inch jet of water to a maximum height of 250 feet at full pressure, and there are also twelve outlets for hose connections, each with main-gauge instantaneous couplings. The monitors are placed forward, amidships and aft, respectively, and each is fitted with wheel and worm gear so that the jet can be directed at any angle. A total volume of 3,000 gallons of water can be discharged per minute. For salvage purposes the pumps have a discharging capacity of over eighteen tons of water per minute. The speed of the craft is eight knots per hour. The float has been designed more especially for coping with conflagrations among the great warehouses on the banks of the canal, wherein is stored highly inflammable freight.—"Scientific American."

Police Boat.—W. A. Boole & Son, San Francisco, are building a 125-ton gasoline schooner for the German government. This vessel is for service in the South seas, where it will be used as a police boat in the ports of the Kaiser's tropical possessions. The schooner will be 106 feet long, and, although equipped with a 125-horsepower gasoline engine, will be heavily sparred and have wings large enough to insure independence of auxiliary power. Commodious officers' quarters will be provided in the after end of the vessel, and the space usually set apart for cargo will be fitted up for the use of native police. The vessel has a very symmetrical model and all her lines are very handsome and graceful. She will have a speed of fifteen knots per hour. —"Marine Review."

MERCHANT SHIPS.

THE NEW CUNARD LINERS.

The Cunard Steamship Line has been regarded, since its inception sixty-five years ago, as a great national institution, largely contributing, as it has done, not only to the development of British shipping supremacy, but also to the evolution on sound lines of marine engineering. The agreement entered into between the Government and the Company about a year ago was therefore regarded with great satisfaction, as it insured, irrespective of cost, the undoubted advantage which accrues from the maintenance of maritime supremacy especially in respect of high speed, and will place at the disposal of the Admiralty ships of great utility for service in war times. Under the agreement the Cunard Company are, as is well known, building two steamers, 785 feet long, to attain a speed of 25 knots. But Lord Inverclide, and his colleagues on the directorate, recognized from their long experience that, while there is a large number of trans-Atlantic passengers who will, at all costs, choose the fastest ship, there are others, probably a great majority of the voyagers, who are satisfied with a moderate speed, provided there is certainty of at least the same measure of comfort as is afforded in the high-speed liners. When fixing the general principles of the high-speed mail ships, the Cunard Company decided upon a great step in advance in connection with what has hitherto been regarded as the "intermediate" class of ship, and orders for two of these vessels, the *Caronia* and *Carmania*, were placed with Messrs. John Brown and Company, Limited, of Clydebank. It is easy to demonstrate that these two ships are of the first class in every element of design, excepting only speed, while the fact that even in this respect they are excelled by only eight or nine ships on the Atlantic gives them a high place among the world's ships.

There are only three or four vessels of greater tonnage than the *Caronia* and *Carmania*, and the difference is due to the aim to carry more cargo in the larger vessels. The *Baltic*, which is the biggest ship afloat, is 48 feet longer, and has a gross tonnage about 2,800 tons greater, while in view of her fuller lines and greater cargo, she will in service have a displacement considerably higher, but her speed on the Atlantic is 17 knots. The over-all length of the *Caronia* and *Carmania* is 678 feet, and the molded breadth 72 feet, making the displacement 29,800 tons when the vessel is fully loaded to a draught of 32 feet. In order to attain a speed of 19 knots under economical conditions a smaller coefficient of fineness was decided upon than has been adopted in previous so-called intermediate steamers, it being under 0.7, which compares with about 0.55 for some cruisers; but with the great length possible in ships for merchant service, the naval architect does not require to fine the ends of his ships to the same extent as in the short, beamy armored vessel. Thus it may be assumed that, even in the 25-knot ship, the coefficient will be somewhere about 0.6. But, to return to the question of size, the molded depth of the *Caronia* is 52 feet, the height from keel to navigating bridge is 90 feet and to the top of the funnels 144 feet. In her construction 12,000 tons of steel were required, with 1,800,000 rivets. Many of the plates were $1\frac{1}{8}$ inches thick, 32 feet long and $5\frac{1}{2}$ feet in width, quadruple riveted with $1\frac{1}{8}$-inch rivets by hydraulic pressure. She may carry 3,450 tons of water ballast, 12,000 tons of cargo, and 300 first, 350 second, 1,000 third and 1,000 steerage passengers. These, with the crew of 450 officers and men, make an aggregate of 3,100. As to the superior character of the accommodation provided for all classes, and the thousand and one details to insure comfort, we hope to deal later, when we publish further illustrations. For the present we may only say that there is nothing wanting in any department of the ship.

Chief interest, however, in connection with the *Caronia* and *Carmania* centers in the propelling machinery. The

former is fitted with quadruple-expansion engines, driving twin screws; for the latter, to be launched on the 21st inst., there is now being constructed at Clydebank an installation of Parsons steam turbines to drive three screws. Opportunity will thus be given of testing the comparative economy of the systems in the Atlantic service; and while doubt as to the potentialities of the newer prime mover have almost disappeared except in the minds of most conservative engineers, the results will always be valuable, so that Lord Inverclyde and his company are to be felicitated not only on the bold step of adopting the system for the 52-knot ships, but particularly for affording means of a thoroughly reliable test in the most severe of steamship services. It may be claimed that, so far as the reciprocating machinery is concerned, full justice will be done as an outcome of the experience of the Clydebank staff, while at the same time a year's continuous research in a special turbine experimental department, and in the ship-model and propeller-testing tank at Clydebank, has enabled Messrs J. Brown and Co., to determine many uncertainties in connection with details as to the design, and especially as to the manufacture, of the turbines. The time has barely come for reviewing this experimental work, but one or two points may be dealt with.

In the first place, however, reference must be made to the reciprocating engines. Standing in the engine room, one could not help being impressed, not only with the great size and suggestion of strength, but also with the easy motion of these engines. There is no longitudinal bulkhead between the two engines, and their appearance when running at ninety revolutions was therefore the more impressive. The total height from the center of the shafts is 30 feet, and from the base of the bed plate 36 feet. The diameters of the respective cylinders are 39 inches, 54½ inches, 77 inches and 110 inches. The latter, with one exception, is the largest cylinder yet adopted for vertical engines. The stroke is 5 feet 6 inches, and the length of the connecting rods is 12 feet between centers. This length is conducive to efficient working, and in

this respect the merchant ship has a great advantage over the warship. In the latter, with engines of corresponding power, the stroke would be only 4 feet 3 inches, with a connecting rod 8 feet 6 inches between centers. Again, the weight allowed for machinery is probably double that placed at the disposal of the warship builder; naval machinery requires to make 40 per cent. more revolutions for full power.

While the naval engine is only expected to run at full speed in cases of emergency, and even then only for short periods, the *Caronia's* machinery has been built to run year in and year out at full speed, irrespective of weather, and consequently many conditions had to be taken into account in the proportioning of parts which do not apply in the case of naval machinery. Merchant-ship boilers are thus made of sufficient capacity to maintain the full power continuously, even when a certain number are shut down for cleaning fires. In the naval service the boilers are usually proportioned to maintain continuously four-fifths of the power, the remainder required for full speed being got under pressure. The *Caronia* boilers, which, along with the engines, were fully described on the occasion of the launch,* have thus 2.35 square feet of heating surface per unit of power, Howden's system of forced draft being used, as against 2.7 square feet for natural draft in cruisers; the power per unit of grate area is 17.3 indicated horsepower and 13 indicated horsepower respectively. The *Caronia's* machinery has been evolved from that of the *Saxonia*, which was tested by the Naval Boiler Committee, and required only 13.4 pounds of steam per horsepower per hour, against 16 pounds in the naval ships tested; while the boilers, with Howden's system of forced draft, generated 12.33 pounds of steam per pound of coal, as compared to 9½ pounds to 11 pounds in the naval ship. The coal consumption per unit of power was 1.29 pounds. There is every promise that in the *Caronia* the results will be at least as good, so that the standard set for comparison with the turbine installation in the

* See "Engineering," Vol. LXXVIII, page 91.

Carmania will do full justice to the reciprocating type of machinery.

As regards the *Carmania*, the only difference will be in the propelling machinery. The form of hull, except so far as modified for the propellers, and the boiler installation, will be exactly the same. There will be, as in all recent installations, three shafts, the center shaft being driven by the high-pressure turbine, while the side shafts will be worked by the low-pressure system, with the go-astern turbine at the after end fitted inside the low-pressure casing. The space occupied, so far as area is concerned, will be the same as in the *Caronia;* there will be a saving in weight by the adoption of the turbine system of about 5 per cent. The boiler pressure will be reduced from 210 pounds, as in the *Caronia*, to 195 pounds in the *Carmania*. The turbines will take steam at an initial pressure of 165 pounds, as against the 200 pounds in the quadruple-expansion engines. Owing to the high vacuum desirable in the turbine system to ensure the fullest economy, the condensing surface, which in the *Caronia* is 27,030 square feet, will be increased in the *Carmania* by 20 per cent., while the capacity of the centrifugal pumps will be increased by about 50 per cent., so that the amount of circulating water that they will be capable of discharging will be from 50 to 60 times the weight of feed water, as compared with a ratio of from 25 to 30 times in the *Caronia* installation.

The trials of the *Caronia*, which took place on Saturday, the 4th instant, and Monday, the 6th instant, gave very satisfactory results. In the first place a series of progressive speed runs was made over the measured mile at Skelmorlie, on the Clyde, with the following mean results:

Revolutions.	Power. Indicated horsepower.	Speed. Knots.
69.6	10,400	15.72
74.5	12,350	16.61
80.9	15,500	17.76
85.2	18,900	18.8
89.	21,600	19.51

After these progressive runs the ship continued at full power for some time, and the highest results during the performance on Saturday, so far as engines were concerned, were as follow: Revolutions of port engine, 90.9; power, 11,550 indicated horsepower; revolutions of starboard engine, 91.2; power, 11,527 indicated horsepower. The collective power was thus 23,077 indicated horsepower. The official full-power trials commenced at noon on Monday. The mean result of four runs on the measured mile was as follow: 89.2 revolutions; 21,870 indicated horsepower; 19.62 knots; and this speed and revolutions were maintained for a total continuous period of 13½ hours. Indicator cards were taken at regular intervals during the trial, and the highest power recorded was about 23,500, the results of the previous trial on the 4th instant being thus verified in all essential details.—Extract from article in "London Engineering."

Virginian, *Launch of.*—On December 22, Messrs. Alexander, Stephen & Sons, Limited, Glasgow, launched the new turbine steamer *Virginian*, 11,200 tons, which has been built for the Allan Line Steamship Company, Limited, of Glasgow. This vessel, with the *Victorian*, now completing at Belfast, will be the first turbine liners to cross the Atlantic. The *Virginian's* dimensions are: Length, 540 feet over all; beam, 60 feet; and depth, 41 feet. She has accommodation for about 1,650 passengers—470 first class, 240 second class and 940 third class. The vessel is specially designed for the conveyance of the Canadian mails and passengers; no less than five decks are fitted up for the accommodation of the latter. She has also considerable cargo space in the holds, fore and aft, one of them being fitted up and refrigerated for the reception of perishable cargo, chilled beef, etc. The first-class dining saloon at the fore end of the bridge is arranged on the modern group system of small tables, each seated for parties of six or eight, and has accommodation for 200 persons. The companion way leads in two flights to the bridge deck, and thence to the promenade deck, where are situated the music room, lounge, library and smoking room. The music room, like the dining saloon, is

treated in the Georgian style, but finished in lightly-stained mahogany below and ivory white above, with richly-figured brocade panels, the upholstery being made to harmonize. There is a large and airy nursery. The second saloon, on the main deck, is arranged to seat over 200 passengers. The cabin accommodation is heated throughout by steam, the pipes being so arranged that each individual passenger can modify the heat to suit himself. The emigrants are kept comfortable by an installation of the thermo-tank system, which combines the duties of heating and ventilation.

The turbines, which are to be supplied by the Parsons Marine Steam Turbine Company, Limited, are expected to prove of ample power to drive the vessel at a high rate of speed, although the space they occupy is considerably less than would have been required by reciprocating engines of equal power, thereby enabling a greatly improved class of accommodation on the upper decks to be provided. Steam at high pressure will be supplied to the turbines by nine single-ended boilers, fitted with forced draft. The boilers and a very complete installation of auxiliary machinery have been supplied from the engine works of the builders, Messrs. Alex. Stephen and Sons, Limited. The *Virginian* is intended to sail on April 6 on her first voyage from Liverpool to Halifax and St. John, N. B.—"Engineering," London, February 10, 1905.

An announcement recently made of the trial of the Allan Line Steamer *Victorian*, in which her turbines were reported as having proven a failure, seems to have been premature—neither the *Victorian* nor the sister ship, the *Virginian*, has as yet had a trial, but it is expected that these will take place about the first of March, at which time the advocates of turbines for steamship propulsion anticipate a very favorable report.

A number of orders for vessels are being held back awaiting the result of the trials of these vessels.

Lama, *Launch of, December 8, 1904.—Lama*, steel turbine steamer; 275 by 44 by 25.6 feet. Built to the order of the

British India Steam Navigation Co.'s Colonial trade. The vessel is of the poop, bridge and forecastle type, having accommodation for first-class passengers in the bridge, for second-class in the poop, and for crew in the forecastle. The first-class passengers are berthed in large, airy cabins fitted with all the conveniences now so common in first-class passenger vessels. The dining saloon, which is capable of accommodating all the passengers at once, is in a Romanesque design, finished in cream enamel, the spandrels between arches being filled in with anaglypta diaper, having a mosaic effect. The second-class passengers are accommodated in large and airy three and four-berthed rooms. The main deck is arranged for the carrying of native passengers. All the passenger accommodation is ventilated by electric fans in addition to natural ventilation. As the ship is intended to maintain a high rate of speed, there is only a limited amount of cargo space. The turbines have been supplied by Messrs. Denny & Co., Dumbarton, along with the boilers and the remainder of propelling machinery. The new steamer is classed with the British Corporation and Lloyd's Registers.—"The Steamship."

The Hamburg-American Line is building not only the two enormous steamers *Kaiserin Auguste Victoria* and *America* for the New York-Hamburg run, but also the following smaller vessels for its other routes: At the Bremen Vulcan Works, the *Rhenania*, *Rhaetia* and *Rugia*, of 5,900 tons each, for the East Asia-Hamburg routes; at Kiel Germania-Werft, the *Borussia*, of 7,500 tons, to be used as an army transport or troopship; at Hamburg, the *Reiherstieg-Schiffswerft*, *Blohm* and *Voss* and the Flensburger Schiffbau-gesellschaft—the three steamers *Polynesia*, *California* and *Columbia*, of 6,050 tons each, for the west coast of South America service; at the Bremerhaven Seebeck and the Howaldt Work at Kiel one steamer each, of 2,000 tons, for the east Asian coasting service; another 2,000-ton liner at the Seebeck for the intercolonial West Indian runs; another at Hamburg—at the Reiherstieg—of 3,800 tons; at the Germania of Kiel and at Fairfield, Glasgow, the

large steamers *Wittelsbach* and *Fursi Bismarck*, of 8,600 tons each. This makes a total of fifteen new steamers being constructed at the same time, with a total gross register of 117,850 tons, which gives the great line a gross total of 141 ocean-going steamers, whose register is 711,856 gross tons, a mighty fleet to fly one house flag.—"American Syren and Shipping."

YACHTS.

Narcissus, *Launch of*, by Fairfield Shipbuilding and Engineering Company, December 20, 1904.

Narcissus, twin-screw turbine yacht, 245 by 27.6 by 16.3 feet. Built to the order of Mr. A. E. Miller Mundy, of Shipley Hall, Derby. She has a Thames measurement tonnage of 782 tons, and has been specially designed by the Fairfield Company, and constructed by them in a most substantial manner in conformity with the requirements of Lloyd's highest yacht class. Appearance being one of the first considerations in a vessel of the pleasure fleet, great attention has been paid to the form of the hull as well as to the lines of sheer, the contours of stern and cutwater, and also to the placing of masts and funnel so as to secure the utmost of symmetry and grace. She has been designed with a continuous main or weather deck, with cabin deck below forward and aft, a long deck house covered by a shade deck amidships, and rail-high forecastle forward. On the shade deck are the captain's room and chart room, with navigation bridge above. In the forward part of the deck house on the main deck is a handsome drawing room, lit by large, square plate-glass windows. This apartment measures about 14 feet square, and will be comfortably warmed by an open coal fire. Aft of the drawing room is the main entrance leading to dining saloon and owner's private apartments on the cabin deck, as well as to the drawing room, and a cozy smoking room, measuring about 14 feet by 10 feet. The position of the galley on the weather deck renders it particularly easy of ventilation, and will obviate any chance of smells in the lower parts of the ship devoted to living spaces. The central deck house is broken by a convenient cross passage from which a ladderway ascends to the shade deck. This passage renders communication easy from side to side without having to go

round the deck house, as is the case in so many large steam yachts.

The engine hatch measures only 14 feet by 8 feet, the small dimensions being rendered possible by the fact that no part of the machinery extends above the main deck. In this casing is the main starting and maneuvering platform. The after portion of the main deck clear of the shelter afforded by the shade deck is occupied by promenade space. On the cabin deck the forward part is taken up by a spacious forecastle fitted up for 18 seamen and firemen. Immediately aft of the crew space are the officers' quarters and mess room, and the owner's private cabin with valet's room. Aft of this is the dining saloon, extending the full width of the vessel, and occupying 17 feet of her length, and to accommodate 12 persons. There are coal bunkers to contain 120 tons of coal amidships, the after hold being occupied by the screw shaft and electric accumulators. The whole of the living quarters are heated by a well-designed hot-water heating system, having a slow-combustion furnace placed in a recess off the main stokehold. This system is in addition to the open fires, and will be very useful in keeping the vessel aired and warmed during lying-up periods. Throughout the vessel electric lighting is fitted. The *Narcissus* carries two steam launches, one of 27 feet and one of 16 feet in length, together with two cutters, one gig and one small dingy.

The vessel, which marks another step in the application of turbine propulsion to vessels of the yachting fleet, is schooner rigged with two pole masts, and has a scroll carving forward representing the flower after which she is named. She will be driven by twin screws, and the propelling machinery consists of two independent Parsons compound steam turbines and one condenser. There is one high-pressure turbine on the port side and one low-pressure turbine on the starboard side of the ship, and a reversing turbine is incorporated with each. These two turbines will each drive a separate shaft with one propeller on each shaft, and the engine room is fitted

with all modern appliances for ensuring economy of working. The boilers for generating the steam are two in number, of the cylindrical, multitubular marine type, constructed entirely of steel, and adapted for a working pressure of 180 pounds per square inch.—"The Steam Ship."

A turbine steam yacht containing several new and interesting features has been recently constructed for Sir George Newnes, M. P., by Messrs. Swan, Hunter & Wigham Richardson, of Newcastle-on-Tyne, from the designs of Sir William White, formerly naval constructor to the British Admiralty. The experience gained by the owner during numerous cruises in various parts of the world has led to the incorporation of some novel features in this new vessel, which is of 1,260 tons. A fundamental idea in the design is the adoption of moderate speed and the utilization of the relatively large dimensions in the best possible accommodation. According to the contract, the maximum speed is to be 15 knots, and for this speed ample power has been provided. With regard to the turbines, it has been stipulated that there shall be unprecedented economy of coal at cruising speeds, which involves a new departure as compared with other turbine-propelled yachts. Very large bunker capacity has been provided. Although primarily coal is to be used, the bunkers have been built so as to be available for oil fuel, for the use of which the cylindrical boilers can be readily adapted. Electric power is to be used for nearly all auxiliary purposes—steering, cable work, warping, boat hoisting, ventilation and heating.—"Scientific American."

Khedive's Yacht.—The old-fashioned engines in the Khedive's steam yacht *Mahroussa* will be replaced by turbine machinery. This vessel, which will have the distinction of being the first royal yacht to be fitted with the new engines, is one of the largest yachts afloat, being 400 feet long, 42 feet beam, and 26 feet 5 inches depth. The reconstruction and alterations to the hull will be carried out by A. & J. Inglis, of Glasgow.—"The Nautical Gazette."

Gasoline Launch.—The Gas Engine & Power Co. and Charles L. Seabury & Co. have secured from Mr. Drexel, of Philadel-

phia, a contract to build a high-speed launch, to be fitted with two gasoline engines, each having six cylinders.

The boat will have a total length of 62 feet, is fitted with twin screws, and designed for a speed of 26 knots.

Motor Boat.—There is building at the Napier Works, in England, a new motor boat, on radical lines, for Mr. Leopold Rothschild. It is expected that she will be very speedy. The skin is to be four-ply cedar and mahogany, with a fine silk lining between, dressed with an elastic preparation. The several thicknesses are sewn together with phosphor-bronze thread. The motor is to have six cylinders, mounted in singles, with large exhaust valves on the port side and equally ample inlet valves on the starboard. The engine, together with all accessory gear, will be installed very low in the boat, to lower the center of gravity of the weights. In front of the large engine there will be a small, single-cylinder starting motor, which drives by means of friction and ratchet clutches on the geared flywheel. All the reversing gears, thurst bearings, etc., will be contained in an oil and watertight casing, and run in submerged oil. Yarrow will make the propellers, and extensive experiments will be carried out.—Extract from "Marine Review."

OBITUARY.

RALPH ASTON, REAR ADMIRAL (Retired).

Born in Connecticut in 1841; descended from Puritan stock; educated at Chase's Seminary. He spent two years' apprenticeship in a machine shop; and was a fair draughtsman and designer before he entered the Naval Service. He entered the Navy in 1861 as a Third Assistant Engineer, and was ordered to the *Cayuga*, a "ninety day" gunboat, which took part in the battles of the lower Mississippi River, passing Forts St. Philip and Jackson, and taking an active part in the destruction of Confederate vessels which were encountered above those forts, and in the attack on Vicksburg. He was in the battle of Mobile Bay, Grant's Pass and Grand Gulf. Mr. Aston was promoted to a Second Assistant Engineer in 1863, and to a First Assistant Engineer in 1866; served on board the *Ashuelot* in 1867, '68 and '69.

In 1869 he was transferred to the *Terror*, on the North Atlantic Station. He served on board the *Omaha* in the Pacific squadrons, 1871, '72 and '73; Naval Rendezvous, New York, 1875 and '76; experimental duty, 1883 to 1885, on board the *Pensacola* and *Kearsarge;* European Station, 1885 and '86; on board the *Ossipee* in North Atlantic squadron, 1886 and '87; he was promoted to a Chief Engineer in 1888, when he served on experimental duty at New York; he served on board the *Bennington* from 1891 to 1894. He was Chief Inspector at the Continental Iron Works, New York, from 1894 to 1897, when he was ordered to the *Cincinnati*, and served on board that vessel during the war with Spain. In October, 1898, he was transferred from the *Cincinnati* to the flagship *Brooklyn*, where he remained until he was promoted to the rank of Captain, when his sea duties terminated. He then resumed inspection duty in New York, where he remained until he was

retired, in January, 1902. His retirement was with the rank of Rear Admiral. His total sea service was 21 years and 3 months.

Rear Admiral Aston was an engineer of a high order, combining the scientific and practical qualities to a high degree. He was a modest, unassuming man, but fearless and indefatigable. His good qualities won for him the esteem of every one he came in contact with, and he justly merited that epithet, endearing to seafaring men, of being a *good ship mate.*

He was an indulgent husband and a kind father.

He died in his home in Brooklyn on the 12th of December, 1904, of cerebral hemorrhage. His death was painless.

He was a member of the Military Order of the Loyal Legion; of the American Society of Naval Engineers, and of the Society of Freemasons. B.

BOOKS RECEIVED.

THE NAVAL CONSTRUCTOR.—SIMPSON.—A very complete and well-arranged hand-book on Naval Architecture. By GEORGE SIMPSON, M. I. N. A. Published by D. VAN NOSTRAND COMPANY.

The book contains many new cuts and tables of useful information, and is especially good in its description of the various standard fittings of ships.

ASSOCIATION NOTES.

The regular annual meeting of the Society was held at the Navy Department, Washington, D. C., on December 24, 1904, for the purpose of electing officers for 1905.

A count of the votes received resulting in the following officers being elected:

President, Commander A. F. Dixon, U. S. Navy.

Secretary-Treasurer, Lieutenant Commander W. W. White, U. S. Navy.

Members of the Council, Captain George W. Baird, U. S. Navy; Commander J. K. Barton, U. S. Navy; Commander W. M. Parks, U. S. Navy.

Rear Admiral W. L. Capps, U. S. Navy, received a sufficient number of votes to elect, but he having requested that his name be withdrawn before the election, it was decided that the nominee receiving the next higher number of votes should be elected.

SPECIAL MEETING OF COUNCIL.

At a special meeting of the Council, held on January 7, 1905, Lieutenant Commander W. W. White, U. S. Navy, tendered his resignation as Secretary-Treasurer, and Lieutenant Charles K. Mallory, U. S. Navy, retired, was elected to fill the vacancy thus created.

The following statement was presented by the retiring Secretary-Treasurer:

Received, 1904:		
Dues and subscriptions	$3,875.40	
Advertisements	1,413.13	
Sales, JOURNALS and reprints	1,114.25	
Total receipts 1904	$6,402.78	
Balance received January 1, 1904	5,939.34	
	$12,342.12	12,342.12
Interest on deposits in bank		120.34
		$12,462.46

Expended:		
Printing JOURNALS	$4,699.89	
Engraving, cuts, etc	262.73	
Underwood typewriter	85.00	
Prize essay and medal	105.00	
Purchase of JOURNALS	305.50	
Lithographs, special	24.00	
Purchase of British Reports	4.41	
Check replaced and payment adjusted	6.32	
Incidentals, postage, telegrams, etc	71.27	
	$5,564.12	
Salary Secretary-Treasurer, 1904	900.00	
	$6,464.12	6,464.12
Credit balance January 1, 1905		$5,998.34

This statement was audited by a committee of the Council and found to be correct.

CHAS. K. MALLORY, *Lieut., U. S. N., Retired,*
Secretary-Treasurer.

A. F. DIXON, *Commander, U. S. N.,*
President.

The Council decided to have prepared a complete index of the JOURNAL, Volumes I to XVI inclusive. Notice will be given when this is ready for issue.

BY-LAWS OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

1. The Association shall be known as the AMERICAN SOCIETY OF NAVAL ENGINEERS.

2. The object of the Society shall be to promote a knowledge of marine engineering and naval architecture by reading, discussing and publishing papers on professional subjects; by bringing together the results of experience acquired by engineers in all parts of the world, which, though valueless when unconnected, tend much to the advancement of engineering when published together in the JOURNAL of the Society; by publishing the results of such experimental and other inquiries as may be deemed essential to the advancement of the science; and historical events in the lives of engineers.

3. The officers of the Society shall be a President, a Secretary-Treasurer, and a Council, all of whom shall be elected annually.

4. The Society shall be composed of Members, Associates and Honorary Members.

5. Officers of the Line and Construction Corps, and ex-officers of the Engineer, Line and Construction Corps of the Navy, and officers and ex-officers of the Revenue Cutter Service shall be eligible as Members.

6. Persons in civil life whose knowledge of engineering is such that they can co-operate with naval engineers in the promotion of professional knowledge, or who are intimately connected with the engineering profession, shall be eligible as Associates.

7. The Secretary of the Navy, the Assistant Secretary of the Navy, the Chief of the Bureau of Steam Engineering of the Navy Department, all ex-Chiefs of the Bureau of Steam Engineering, the prize essayist of each year, and such other persons as the Society may elect, shall be Honorary Members.

8. Members shall be admitted upon application and payment of the annual subscription.

9. An Associate may be admitted upon application in writing and payment of the annual subscription, provided his application have the recommendation of a member, and receive the approval of a majority of the council.

10. Associates shall be entitled to all the privileges of Members except voting and holding office.

11. To be eligible as Honorary Member the candidate must receive the unanimous vote of the Council before his name shall be presented to the Society; and the favorable vote of two-thirds of the Members voting shall be necessary for election.

12. The direction and management of the affairs of the Society, and the editing and publishing of the JOURNAL, shall be vested in a Council composed of five members, the President and the Secretary-Treasurer being members *ex officio*. The Council may appoint one of its number Librarian.

13. The President shall exercise the usual duties of that office.

14. The Secretary-Treasurer chall conduct the correspondence of the Society and its financial transactions. He shall submit an annual statement of the receipts and expenditures of the Society, which shall be audited by three other members of the Council.

15. The Council shall have authority to fill vacancies which may occur during the year.

16. Subscriptions and all matter intended for publication, shall be sent to the Secretary-Treasurer; but no paper shall be read before the Society at the annual meeting, nor anything published in the JOURNAL, without the approval of the Council.

17. In deciding matters pertaining to the Society, none but members shall be entitled to vote; to constitute a quorum for business, nine members must be present.

18. The Society shall meet annually in the City of Washington, and at such other times and places as meetings can be conveniently arranged.

19. The annual subscription shall be five dollars, payable in advance.

20. Copies of the JOURNAL may be sold by the Society at a price which shall be fixed by the Council.

21. Absent members voting on any proposition must state over their signatures whether they are for or against the proposition.

22. On the first Tuesday in October a meeting of the Society shall be held for the consideration of nominations to offices falling vacant under the rules. Nominations to office must be made in writing, and may be made by any member, whether present at the meeting or not. The consent of the nominee to accept office if elected must be assured. A necessary qualification of all nominees, besides full membership, is residence in or near Washington during the term of office.

23. After the nominations are all made, lists of the candidates for the different offices shall be prepared by the Secretary-Treasurer, and mailed to all members of the Society. Each voting list must be signed, and must show under the different offices the name of the person voted for. Each voter will enclose his ballot in a sealed envelope, which will be sent to the Secretary-Treasurer previous to the annual meeting. At the annual meeting the envelopes will be opened and the votes counted.

24. Nothing in the preceding section shall preclude the name of any candidate from being put in nomination for more than one office. In case of a tie, the presiding officer shall decide. Voting by proxy is prohibited.

25. In the event of a candidate receiving the greatest number of votes for more than one office, he shall decide which he will accept.

26. Any office falling vacant in the course of the year owing to the death, resignation or removal from Washington or vicinity of the incumbent, shall be filled by vote of the members of the Council remaining.

27. Motions to amend these By-laws, or to make new By-laws, must be in writing, and must lie over at least three months, during which time notice thereof shall be sent to all members; and the assent of two-thirds of the members voting shall be necessary to amend or adopt.

AMERICAN SOCIETY OF NAVAL ENGINEERS—1905.

OFFICERS FOR 1906.

President:

Commander **A. F. Dixon**, U. S. Navy.

Secretary and Treasurer:

Lieutenant **Chas. K. Mallory**, U. S. Navy (retired).

Council:

Captain **George W. Baird**, U. S. N.
Commander **A. F. Dixon**, U. S. N.
Commander **J. K. Barton**, U. S. N.
Commander **W. M. Parks**, U. S. N.
Lieutenant **Chas. K. Mallory**, U. S. N. (retired).

HONORARY MEMBERS.

The Secretary of the Navy.....Navy Department, Washington, D. C.
The Assistant Secretary of the Navy.....Navy Department, Washington, D. C.
Charles Whiteside Rae, Rear Admiral, U. S. N., Engineer-in-Chief,
Navy Department, Washington, D. C.
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B. F. Isherwood, Chief Engineer, U. S. N. (retired).....111 East 36th street, New York, N. Y.
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Geo. W. Melville, Rear Admiral, U. S. N. (retired).....Union League Club, Philadelphia, Pa.
George R. Dunell, Esq.....33 Spencer Road, Chiswick W., England.

Prize Essayists.

W. W. White (1897), Lieutenant Commander, U. S. N.
W. F. Durand (1898).....Sanford University, California.
B. C. Ball (1899).....Willamette I. & S. Works, Portland, Oregon.
W. F. Worthington (1900), Commander, U. S. N.
J. R. Edwards (1901), Commander, U. S. N.
F. W. Bartlett (1902), Lieutenant Commander, U. S. N.
Charles W. Dyson (1903), Lieutenant Commander, U. S. N.

MEMBERS.

Adams, Robert B., Engineer, U. S. R. C. S.....U. S. S. *Algonquin*, San Juan, P. R.
Addicks, W. R., Vice President Consolidated Gas Company...No. 4 Irving Place, New York, N. Y.
Allderdice, W. H., Lieutenant Commander, U. S. N.
Allen, F. B., Vice-Pres. Hartford Steam Boiler Insp. and Ins. Co.,
Residence, 61 Willard street, Hartford, Conn.
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Bennett, K. M., Lieutenant, U. S. N.
Bieg, F. C., Lieutenant Commander, U. S. N.
Bowers, F. C., Lieutenant Commander, U. S. N.
Bowers, J. T., Lieutenant, U. S. N.
Boyd, David F., Lieutenant, U. S. N.
Brady, John R., Lieutenant, U. S. N.
Bray, Chas. D., Professor Civil and Mechanical Engineering.....Tufts College, Mass.
Brinser, H. L., Lieutenant, U. S. N.
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Fry, Alfred Brooks, U. S. Treasury Service, Lieutenant Commander, Naval Brigade, S. N. Y.,
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Gage, Howard, Lieutenant Commander, U. S. N.
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McKean, Fred G., Chief Engineer, U. S. N. (retired),
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McKean, J. S., Lieutenant Commander, U. S. N.
McLean, Ridley, Lieutenant, U. S. N.
McMorris, B. K.....Wetumpka, Ala.
Maccoun, W. E., Chief Engineer, U. S. R. C. S.....U. S. R. S. *Gresham*, Tompkinsville, N. Y.
Macomb, D. B., Chief Engineer, U. S. N. (retired),
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Martin, F. C., Ensign, U. S. N.
Mathews, C. H., Lieutenant Commander, U. S. N.
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Morrison, F., Lieutenant, U. S. N.
Moses, S. E., Lieutenant, U. S. N.
Munroe, C. W., Chief Engineer, U. S. R. C. S.....U. S. S. *Dallas*, Ogdensburg, N. Y.

Naile, F. R., Lieutenant, U. S. N.
Norris, William, Ensign, U. S. N.
Norton, H. P., Lieutenant Commander, U. S. N.....Navy Yard, New York, N. Y.
Nulton, Louis M., Lieutenant, U. S. N.
Nutting, D. C., Naval Constructor, U. S. N.....Navy Yard, New York, N. Y.

Offley, C. N., Lieutenant, U. S. N.

Palmer, J. E., Lieutenant Commander, U. S. N.
Parks, W. M., Commander, U. S. N.
Patton, J. B., Lieutenant, U. S. N.
Payne, F. R., Lieutenant, U. S. N.
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Kaigunk, Daigak-o.....Naval Staff College, Tsukiji, Tokyo, Japan.
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Karljohansverns Verft.....Horten, Norway.
Kazama, T.....10 Nishikatamachi, Komagomé, Hongoku, Tokyo, Japan.
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Milner, J. W., Engineer Lieutenant, R. N.....H. M. S. *Aboukir*, Mediterranean Station.
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Tappen, A. B......263 W. 73d street, New York, N. Y.
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ERRATA.

No. 1, Vol. XVII.

Page 12.—Change heading of first table from "Port Engine" to "Starboard Engine," and change heading of second table from "Starboard Engine" to "Port Engine."

Page 66.—Under heading "Engine Data," line 18, change "Net area of both L.P. to H.P. pistons" from 2.72 to 7.52.

Page 68.—Under the heading "*Maryland*" interchange the two columns for "cylinder clearances, top."

Page 192.—In third column of tables, headed "length of Sections," for *Dubuque* and *Paducah*, change from 8–2 to 9–2.